

NASA-CR-205084

Semiannual Technical Progress Report

**Aeromover Systems Corporation
3045 Broad Street
Dexter, MI 48130**

Contract # NAS1-20640

This report covers the third six month period of the subject contract from January 26, 1997 to July 26, 1997. The contract statement of work covers four specific applications of Aeromover's 'N'-output differential technology that are being developed in cooperation with industry and NASA. A quantitative description of work, project difficulties, proposed solutions, and a statement of the work that will be performed during the next six months has been included for each of the four projects.

Contract # NAS1-202640 development projects:

1. Robotic Gripper for industrial application
2. End-effector design for NASA application
3. Nut-runner for simultaneous torquing of multiple threaded fasteners
4. Multiple output drive for power auto seats

1. Robotic Gripper for industrial application

A four output differentially powered end-effector has manufactured and tested for use at our collaborating manufacture's facility (Variety Die and Stamping). During the past six months, the prototype device has gone through several small design adjustments and mechanical "tweaking" typical for this type of first-iteration equipment. Strain gauges used to test the torque at the output/fingers showed that drag coefficients at each differentiated output were inconsistent when measured at angles of incidence not parallel with respect to the ground plane. Our investigations revealed that this was primarily due to deficiencies in precision in bushing and bearing supports. Bearing supports were modified and these problems were overcome.

Because the chosen task for demonstrating our industrial end-effector does not require a particularly precise differential mechanism it is possible that the first iteration would have been sufficient for the chosen tasks without modification. However, the Principal Investigator, Mr. Srinivas Bidare' and Aeromover personnel felt that design refinements were necessary to gain a better hands-on understanding of ancillary issues effecting the performance the differential driving mechanism. Investigation has revealed that several specific areas where designers will need to focus attention if precision performance is to be attained. These areas include the following:

- 1 Overcoming the inertial load of the gear train, while supported at various angles. (Critical to driving motor/actuation).
- 2 Supporting bearings & bushings design/location (Necessary for gaining nearly equivalent drag co-efficients at each differentiated output).
3. Design of consistent finger actuation mechanisms that are low mass and not subject to excessive drag. (Slide mechanisms designed for the current model are adequate, however, they prove to bulky for more precision applications).

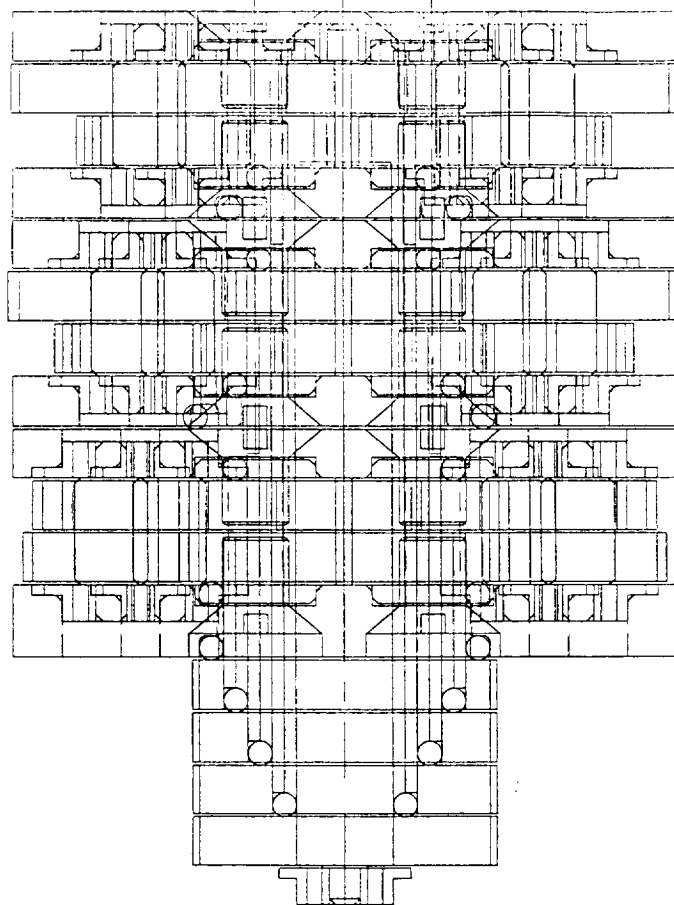
Eastern Michigan University (EMU) has received a refurbished PUMA robot, which is being used to create a mock-up test sight that will simulate tasks in the manufacturing environment. The EMU test site is being used so that any unforeseen problems with the new robotic system can be resolved prior to actual system installation. The test site will also offer the opportunity to more easily collect cycling information. When the system has proven its readiness in the laboratory it will be brought to the manufacturing facility and installed. After installation the end-effector will be examined on a regular basis to monitor for any potential problems. The manufacture will be given the opportunity to evaluate performance of the new system for several months, using the EMU robot, before deciding whether or not a system will be permanently installed, at which time the EMU robot will be returned to the University. By the end of the contract period the system will be installed at Variety Die and they will be evaluating it's performance.

2. End-effector design for NASA application/design iterations

Discovering a specific NASA application for our differentially powered end-effector was delayed due to difficulties in breaking through to program end-users and designers and in receiving their specifications for automated tasks. Lack of progress in this area resulted in Aeromover requesting that project technical monitor, Walter Hankins, assist us in finding an appropriate contact within NASA, that could supply Aeromover with appropriate design specifications. Mr. Hankins supplied Aeromover with contacts at Johnson labs in Houston, with whom a dialogue has begun. By the end of the contract period Aeromover will supply a design to meet the design criteria of a specific NASA end-effector mission.

During the past six months, in lieu of having an actual specific application from NASA, the Principal Investigator began designing a "lightest weight" and "least massive" configuration of the "N-output" differential gear train. This gear train is seen as an extremely promising for application in prosthetic devices or in other applications where the miniaturization of

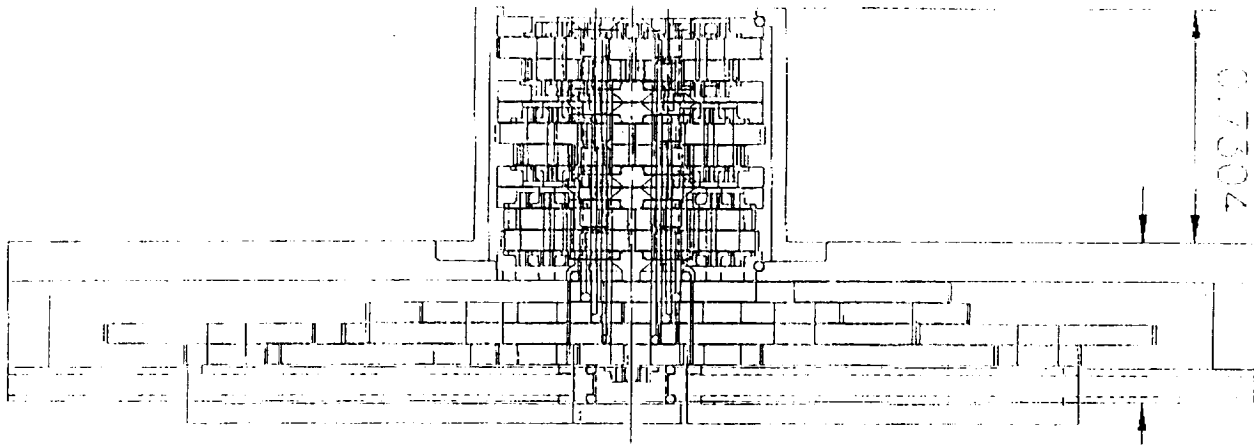
component/mechanisms is critical. NASA's Johnson lab is primarily working with astronaut interface to specific "hand-like" functions being carried out in space. Our flexible, compliant, durable, and light weight mechanism could prove be very appropriate. The following drawing shows our most recent design iteration for a miniature high-speed four output differential.



The device shown is less than 1" in diameter and slightly more than 1" in total length.

The design shown here is capable of driving the four pounds of gripping force necessary for our current industrial application presuming that gear reductions are made at some point after the differentiated outputs. A generic rule in designing differentially driven mechanisms is that the gear train can be made smaller and lighter if the reduction is done at the end of the differential rather than before it. Therefore, handling heavier payloads with a small mechanism requires that greater gear reduction occur after differentiation. In applications such as a prosthetic hand, there are several opportunities to accomplish reduction after differentiation and this type of mechanism would be ideal. Specific task work loads and product design constraints will indicate whether or not the smaller scale differential will prove practical. The following drawing illustrates how the miniature gear

train could be used to build an end-effector that could carry out our current industrial manufacturing task.



The drivetrain shown here offers a dramatic reduction in the size and weight vs. our current device. EMU Principal Investigator Prof. Max Kanagy has been concurrently carrying out design calculations with Mr. Bidare' to develop a slightly larger drivetrain, approx. 2" diameter and 2.5" height, that would not require post-differentiation reduction to accomplish our 4 pound workload requirement. Currently, Dr. Kanagy's work seems the most well suited to most industrial applications, while Mr. Bidare's seem best suited to more specialized applications such as "high-end" prosthetic devices.

In the last six months Aeromover has been weighing the benefits of different differential designs for potential applications at both Ford Motor Company and for Delphi automotive. (Both companies advanced Robotics departments have asked Aeromover to propose an end-effector developmental proposal). In the next six months we will make proposals to both corporations based on their specific design criteria. Similarly we will also obtain an appropriate set of specific design requirements from NASA Johnson and apply the most effective version of a differential mechanism to a their specific requirements.

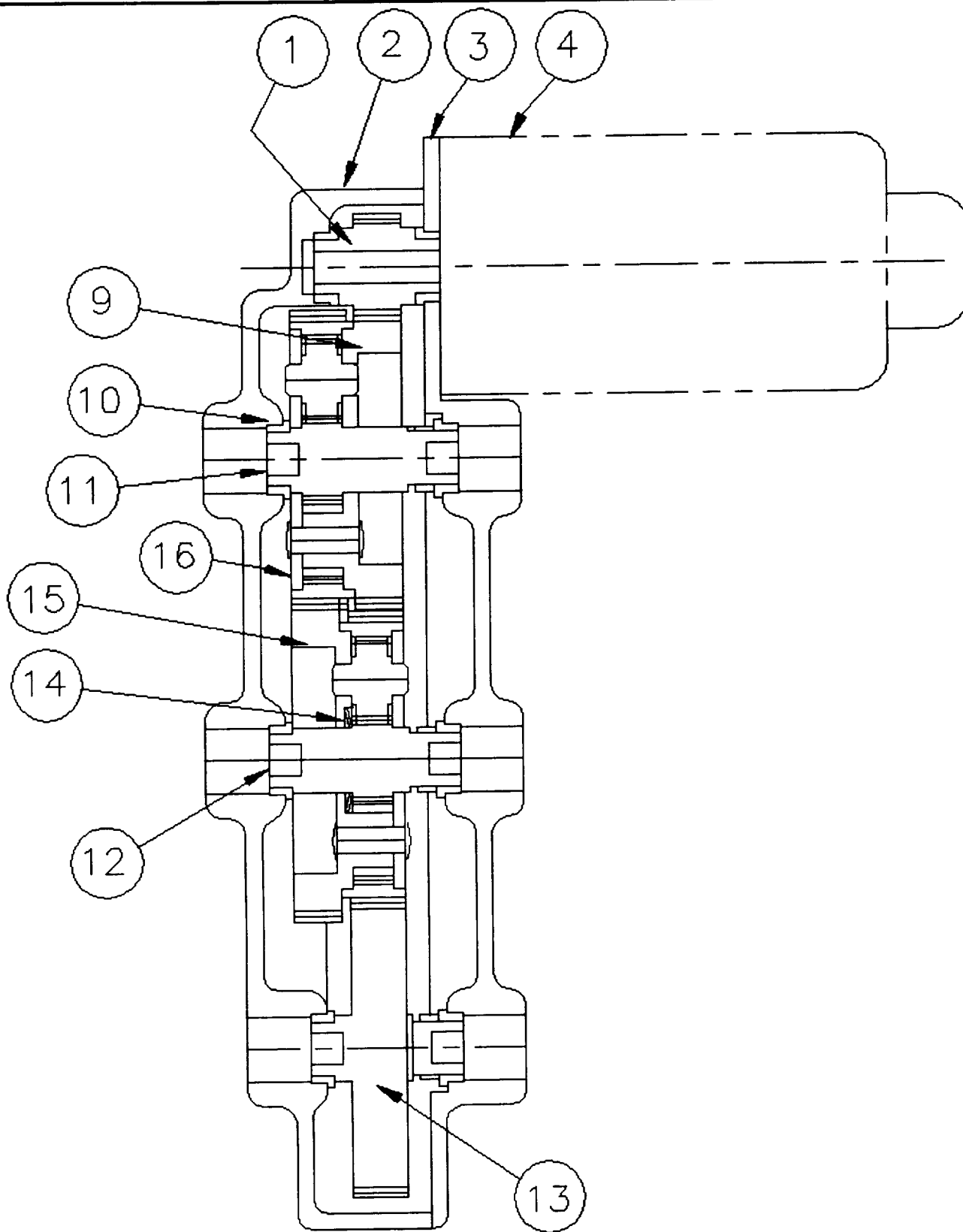
3. Nut-runner for simultaneous torquing of multiple threaded fasteners

Designs for an eight output nut-runner have been completed for use at Tecumseh products. A final design evaluation (outside engineering check) is being conducted by our design subcontractor, South Lyon Design. Tecumseh's existing nut-runner frame is being replicated, by Tecumseh, for Aeromover to use in testing the new machine. We expect delivery of the Tecumseh frame in from 6-8 weeks and completion of the differential drive mechanism within 10 weeks. Testing will then begin and take form 2-4 weeks. We expect to deliver the machine to New Holstein, Wisconsin within the next 16 weeks. Drawings for the nut-runner are attached at the end of this report.

4. Multiple output drive for power auto seats

Our originally proposed Industrial Collaborator for manufacturing a prototype six-way seat drive mechanism, Johnson Controls Inc. (JCI), has not responded to Aeromover proposals in a timely enough manner to meet the demands of our STTR schedule. Therefore, a second seat-drive manufacture, Delphi Automotive, has taken JCI's place as our industrial collaborator. Delphi has offered to fund the development of the prototype seat drive, contingent upon intellectual property agreements that would ensure that they would not pay royalty on any findings made during prototype developments which they help to fund, they also wish to hold exclusive rights to any new technologies developed for the next three years. Aeromover is planning to proceed with the Prototype development, but, has taken several steps to better ensure that our product/technology can not be "held-up" by our collaborator should they choose not to use the new technology. We want to ensure that the technology has the best possible chance of actually being implemented rather than being "sat-on" by a major manufacturer.

Aeromover has therefore completed designs for a seat mechanism to the industrial prototype level. Manufacturing processes and sources have been quoted and two potential manufacturers approached. (Drawings for the seat drive mechanism and assembly plans are attached at the end of this report.) Aeromover has now completed more work on this project than was originally proposed under NAS1-20640. We have taken these extra steps to ensure that the product we are developing actually has a reasonable chance for wide spread use. We anticipate that within the next six months that agreements will be finalized with Delphi and that a prototype device will be tested. (Build of this prototype is not overly complex or time-intensive). If, however, these developments would jeopardize our corporate position, we will contact NASA contracting officers and attempt to get exceptions made to the specific terms of the STTR.

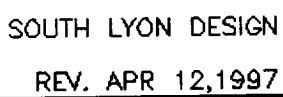


SOUTH LYON DESIGN
REV. APR 12, 1997

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AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



**BRAKE ASSEMBLY
FOR 3 OUTPUT SEAT ASSEMBLY**

NOTES:

REVISION RECIEVED APR 9 1997

- 1 CHANGE GEAR 1 TO DOUBLE HUNG
- 2 ELIMINATE LEFT SIDE ALUMINIUM SUPPORT PLATE, INTEGRATE BUSHING INTO PLASTIC MOLDED HOUSING
- 3 BUSHING MADE OF HARDENED STEEL W/ GREASE PACKED DURING ASSEMBLY
- 4 SUN GEAR IS MADE OF POWERED METAL, INTEGRATED SHAFT AND HAS SQUARE HOLE FOR CABLE DRIVE
- 5 RING GEAR IS MADE OF POWERED METAL
- 6 PLANET GEARS MADE OF POWERED METALOR COLD HEADED STEEL OR INJECTION MOLDED PLASTIC, SHAFT IS INTEGRATED INTO GEAR
- 7 COVER PLATE OF PLANETARY CAN BE MADE OF HIGH CARBON STEEL STAMPING WITH HOLES THICKNESS MAY HAVE TO BE INCREASED TO REDUCE BEARING STRESS ON RING GEAR
- 8 ARM TO BE MADE OF POWERED METAL WITH LIGHTING HOLES OR PROFILE.
- 9 OLD PLATE 3 - SNAP FIT INTO MOLDED PLASTIC HOUSING
- 10 BRAKE LEVER MADE OF PLASTIC WITH INTEGRATED SHAFT AND SPRING - NO FASTENER
- 11 SOLENOID CAPTURED SNAP FIT AND HOUSED IN HOUSING
- 12 NO RIVETS, SHAFTS ETC TO CAPTURE BRAKE OR LEVER

NOTES:

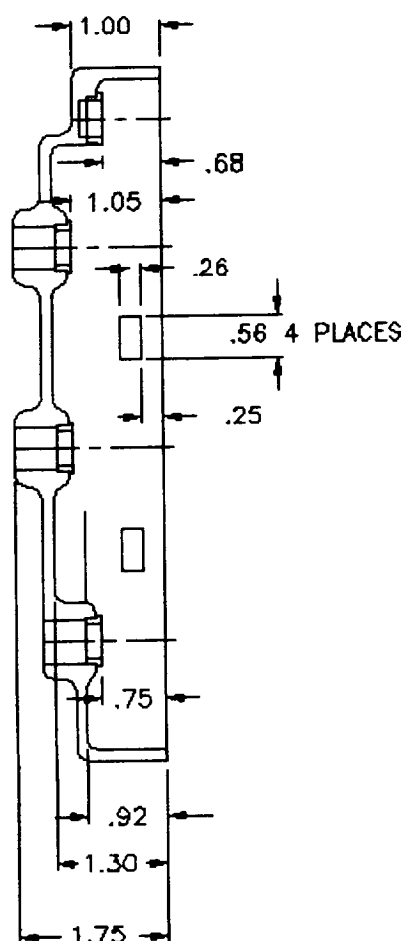
AEROMOVER TO VERIFY TORQUE AND RPM OF ALL OUTPUT SHAFTS

AEROMOVER TO VERIFY GEAR SIZE AND CAPABILITY FOR PRODUCT REQUIREMENTS

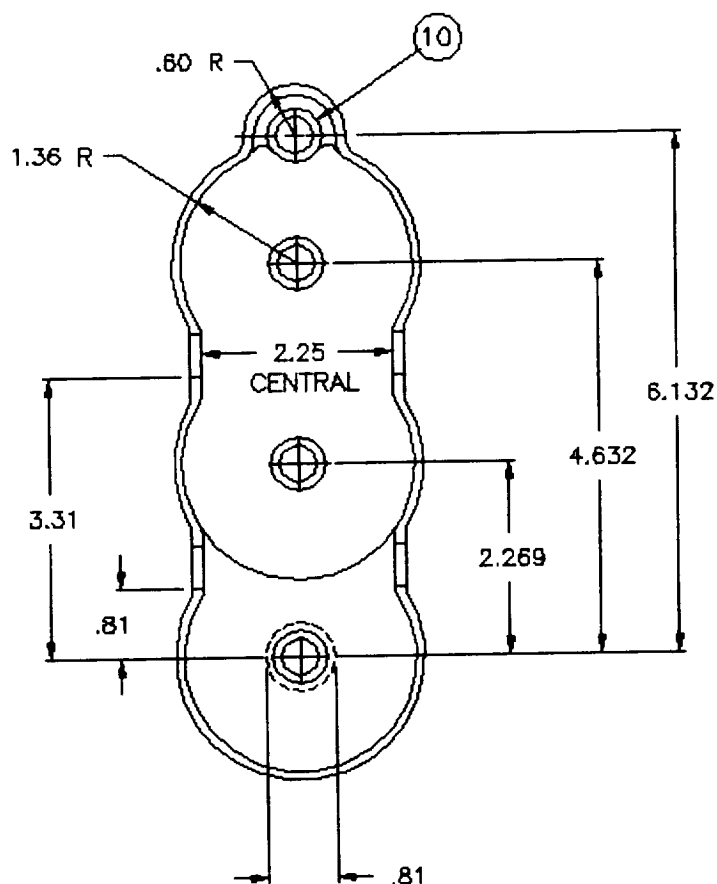
SOUTH LYON DESIGN

REV. APR 12,1997

		ENGINEER	DATE	AEROMOVER INC
				3 OUTPUT SEAT DRIVE
				FOR FLEX SHAFT 6 OUTPUT



WALL = 1/8"
FILLET = 1/8"



2

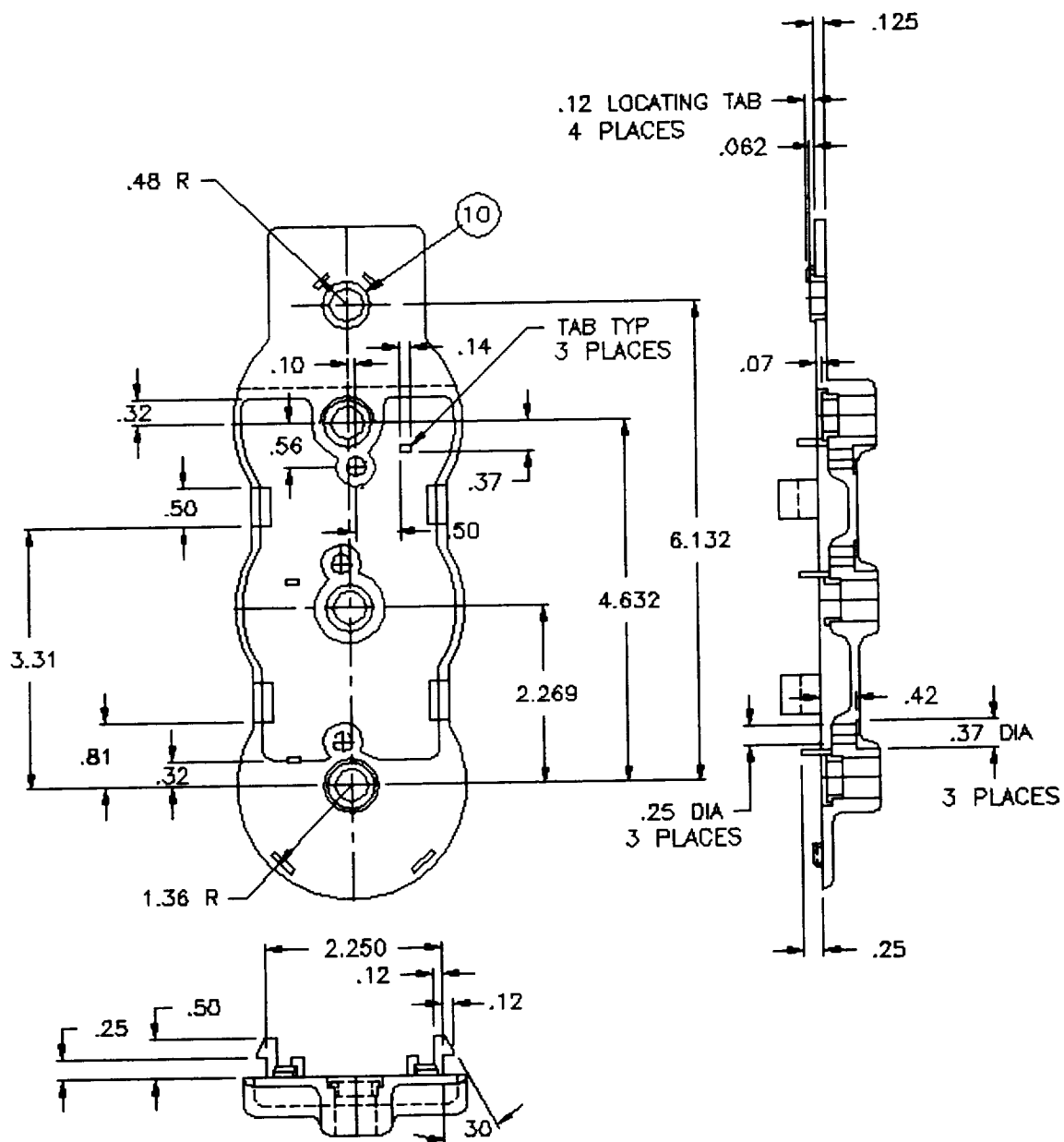
HOUSING MAIN
PLASTIC
QTY(1)

SOUTH LYON DESIGN
REV. APR 12, 1997

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AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



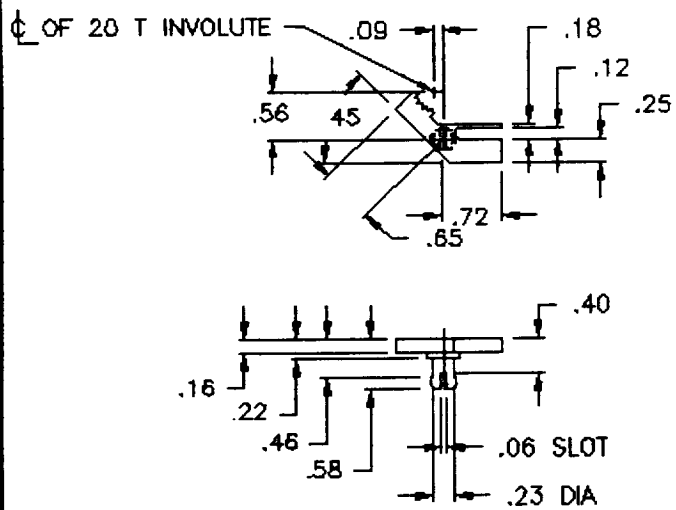
WALL = 1/8"
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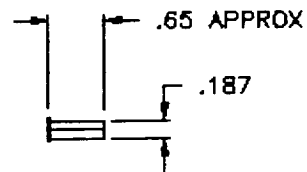
AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



⑤ LATCH
PLASTIC
MOLDED

QTY 3



⑦ RIVET
QTY (6)

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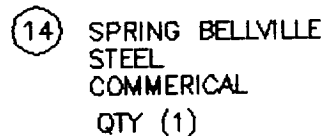
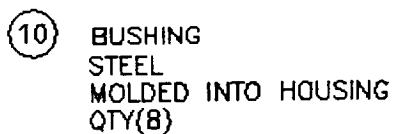
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AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



1 GEAR INPUT
STEEL
QTY (1)



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AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT



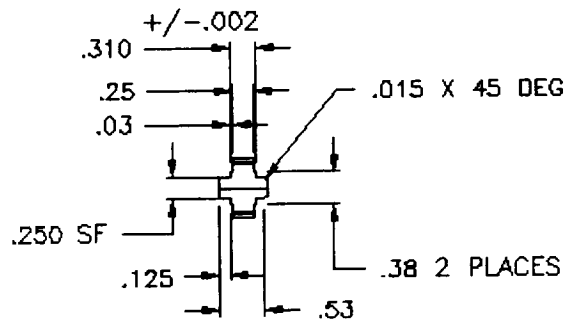
12 SHAFT OUTPUT
STEEL
QTY (1)



11 SHAFT OUTPUT
STEEL
QTY (1)

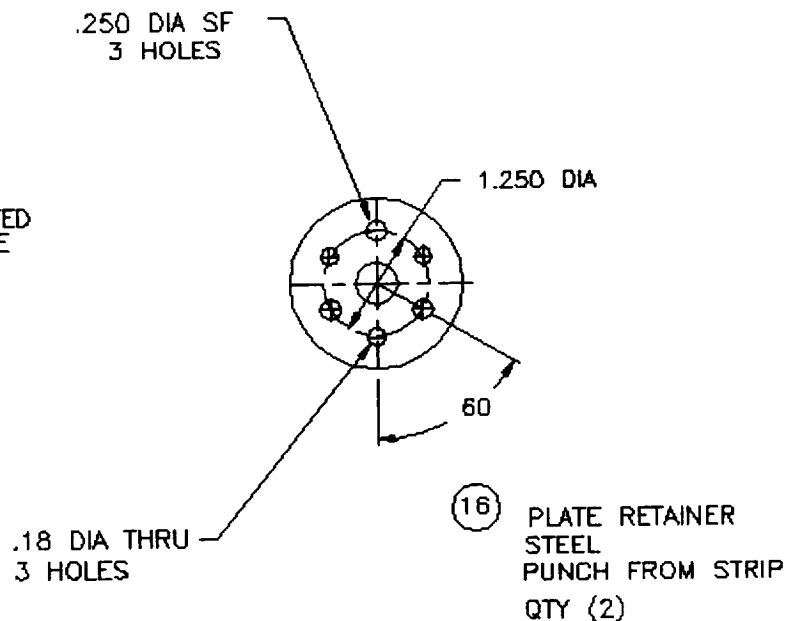
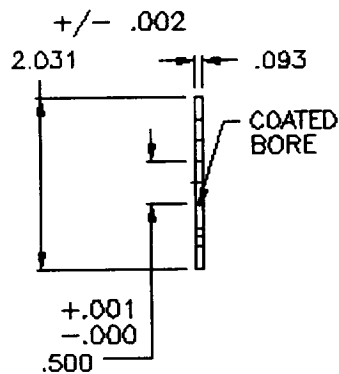
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SOUTH LYON DESIGN
REV. APR 12, 1997



GEAR
NO OF TEETH 20
DIAMETRICAL PITCH 32
PITCH DIAMETER .625

(6) GEAR
~~NYLON~~ STEEL
MOLDED
QTY (6)



SOUTH LYON DESIGN
REV. APR 12, 1997

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AEROMOVER INC

3 OUTPUT SEAT DRIVE
FOR FLEX SHAFT 6 OUTPUT

**AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT**

OPER	DESCRIPTION	OPERATOR TIME	MACHINE TIME	MANPOWER		
				#1	#2	#3
10	ASSEMBLY DIFFERENTIAL (12 SEC PER ASSEMBLY)	28	28	28		
20	ASSEMBLY LOWER HALF	16	*			
30	ASSEMBLY UPPER HALF	12	*		28	
40	JOIN HALF , PRESS & GREASE	8	10			
50	MOUNT MOTOR	5	*			
60	TEST & MARK PART	8	19			
70	PACKAGE FOR SHIPMENT	7	*			28
	TOTAL LABOR TIME (SEC/UNIT)	84	28			
	PRODUCTION RATE (PC/HR)		128.57			
	ANNUAL UNITS/SHIFT		257142.86			
	MANPOWER @ PROD. RATE	3.00				
	LABOR RATE		\$50			
	LABOR COST PER PIECE		\$1.17			

**AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT**

EQUIPMENT

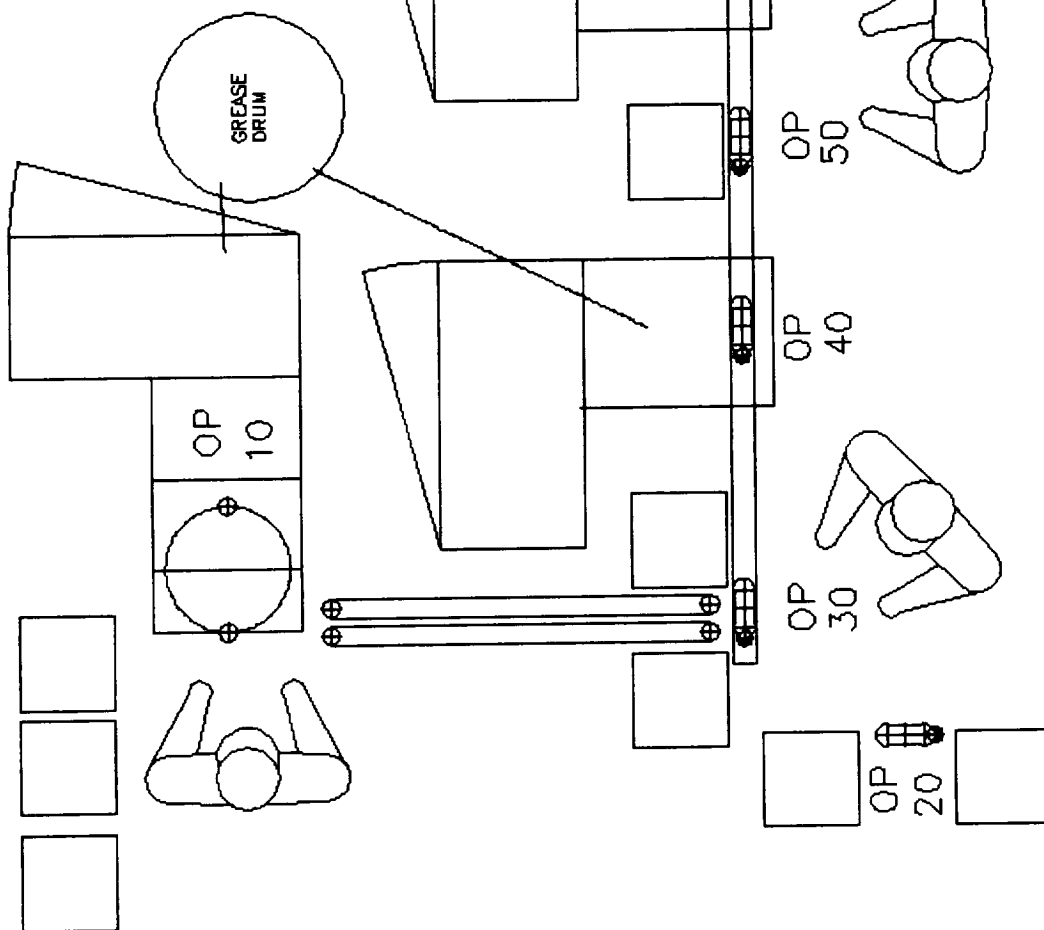
MACH DESCRIPTION

10 INDEX PRESS & GREASE	OPERATOR TIME	MACHINE TIME
INDEX 180 DEGREE	*	2.00
ADVANCE PRESS		2.00
PRESS COVER		1.00
STAKE 3 RIVETS		4.00
RETRACT PRESS		2.00
MANUAL UNLOAD	2.00	
ASSEMBLY		
RIVET (3)	3.00	
BASE	2.00	
PLANETARY GEAR (3)	3.00	
COVER	2.00	
TIME (SEC)	12.00	11.00
40 PRESS HALF & GREASE		
LOAD HALVES	4.00	
PRESS TO POSITION		2.00
INJECT GREASE (8 PLACES)		4.00
UNLOAD	2.00	
TIME (SEC)	6.00	6.00
60 TEST PRODUCT		
LOAD ASSEMBLY	2.00	
CONNECT LEADS	2.00	
STALL TEST		3.00
SOL 1 TEST		3.00
SOL 2 TEST		3.00
SOL 3 TEST		3.00
SOL 2&3 TEST		3.00
REV TEST		4.00
DISCONNECT LEADS	2.00	
UNLOAD	2.00	
	8.00	19.00

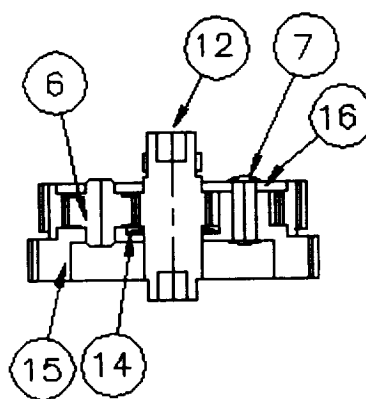
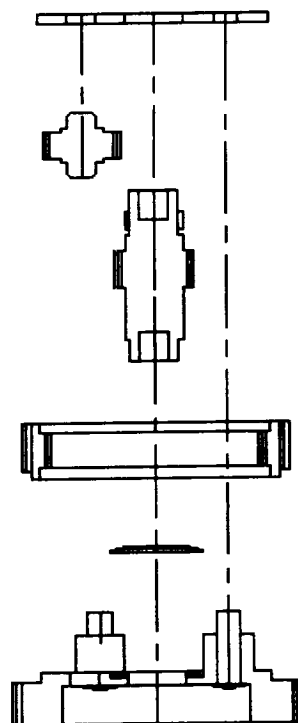
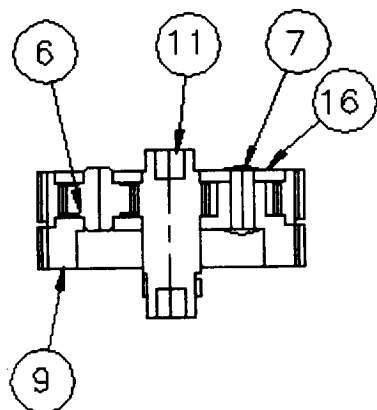
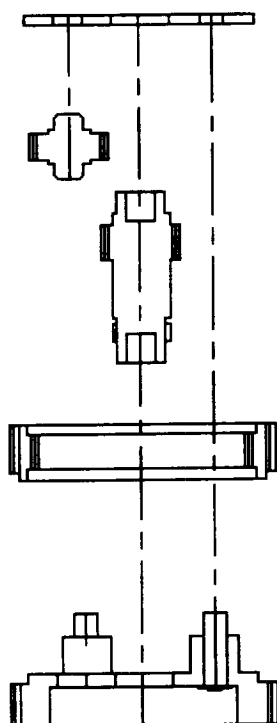
AEROMOVER INC
PREIMINARY ASSEMBLY OF
6 OUTPUT SEAT UNIT

50	TRACK (6FT) ESCAPEMENT & LATCH		
60	TEST MACHINE CONPONENTS BASE LOWER SLIDE SPEED OUTPUT DEVICES (4) TEST MOTOR CURRENT & VOLT BASE ELECTRICAL CONNECTOR TORQUE BRAKE (1) MARKING SYSTEM PNEUMATIC SYSTEM ELECTRICAL CONTROLLER TRACK SECTION (6 FT) ESTIMATE BUILDER MARKUP CAPITAL COST		\$125,000 30.00% \$162,500
	QUALITY CONTROL ITEMS PC, STORAGE BACKUP, SPC, SHIP, DATA HIGHWAY, ETC		\$30,000
	CAPITAL COST CAPITAL COST/UNIT		\$452,500 \$1.76
FLOOR SPACE	40	X	60.00 2400.00 \$12 \$28,800 \$0.11
	COST PER PIEC		\$0.11
	TOTAL COST PER PIECE		\$3.04

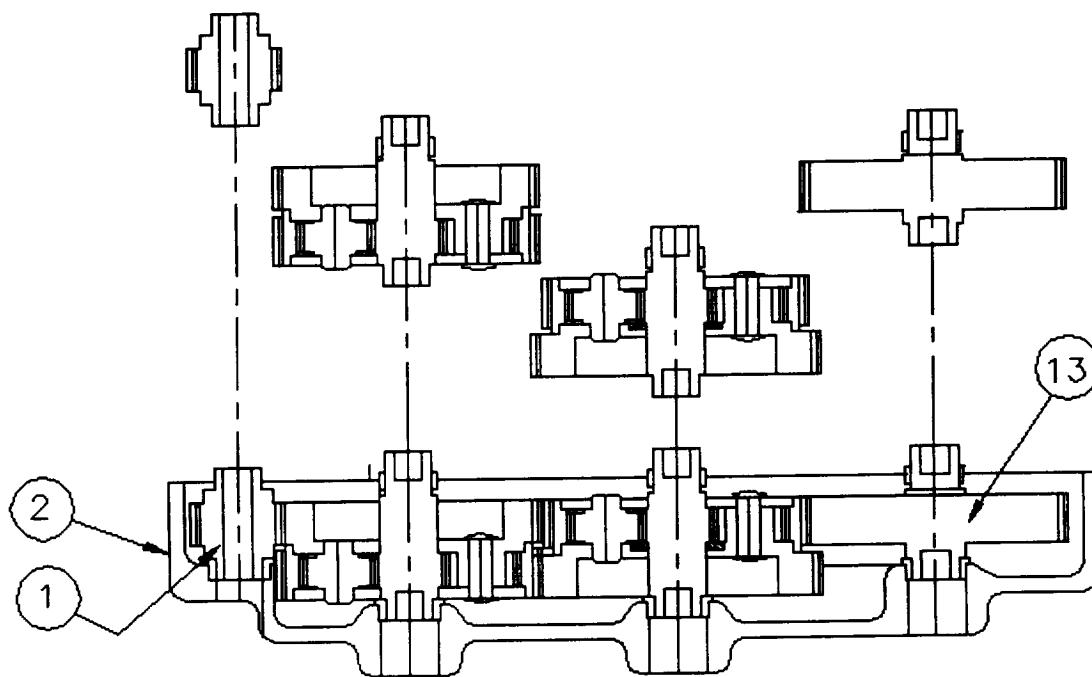
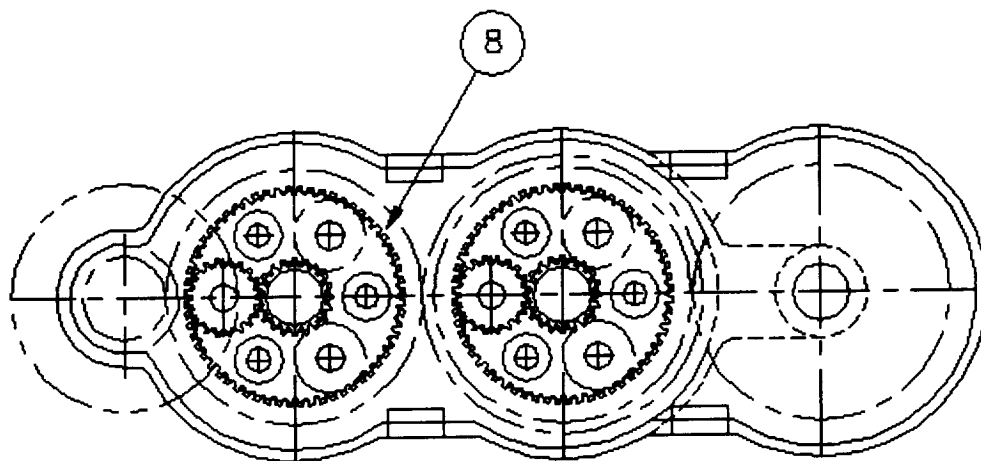
OP	DESCRIPTION	EQUIPMENT
10	SUB ASSEMBLE DIFFERENTIAL COMPONENTS & STAKE HALF	ASSEMBLY PRESS WITH INDEX TABLE
20	SUB ASSEMBLE LOWER HALF WITH GEARS	BENCH FIXTURE
30	SUB ASSEMBLE UPPER HALF WITH BRAKES(4), SOLENOID (3) & WIRING	BENCH FIXTURE
40	JOIN UPPER & LOWER HALVES	ASSEMBLY PRESS WITH GREASE UNIT
50	PRESS ASSEMBLY MOUNT MOTOR	BENCH FIXTURE
60	CONNECT CABLES, TEST SOLENOID RPM, DIRECTION & DRAG. DISCONNECT CABLES & SHIP	TEST MACHINE



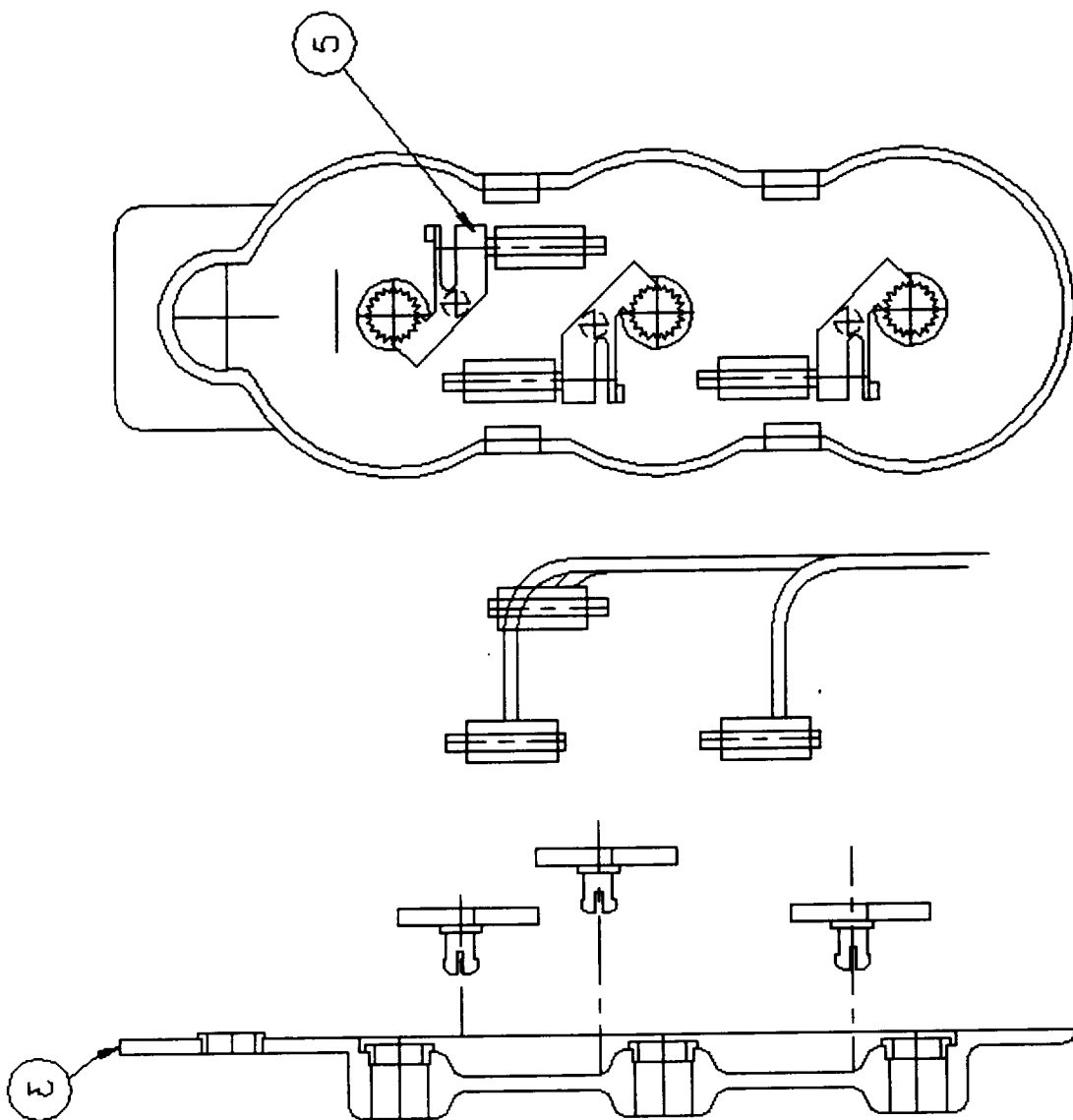
144' (12') X 240' (20')



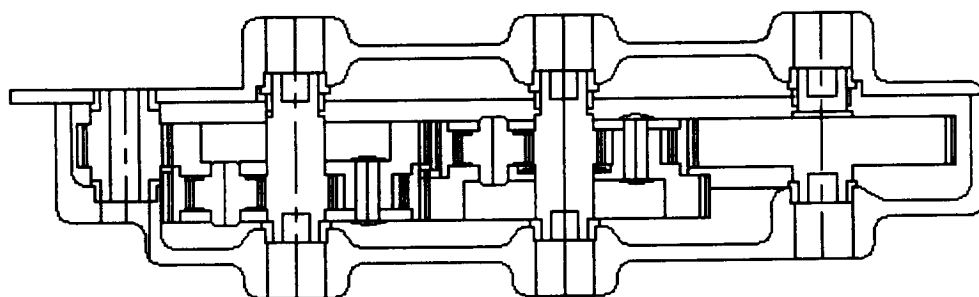
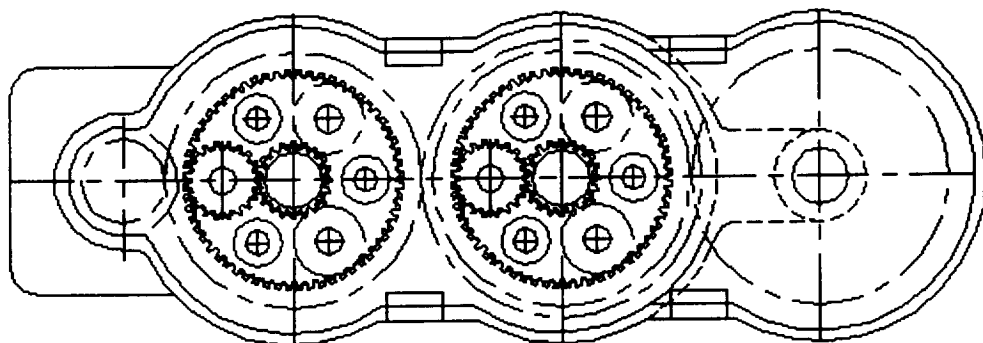
OPERATION	SUB ASSEMBLE DIFFERENTIAL COMPONENTS AND STAKE RIVETS					
TIME CYCLE		PER ASSEMBLY				
EQUIPMENT	ASSEMBLY PRESS WITH INDEX TABLE					
COST ESTIMATE						
OPERATION NO 10				ENGINEER	DATE	AEROMOVER INC BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY
SOUTH LYON DESIGN						



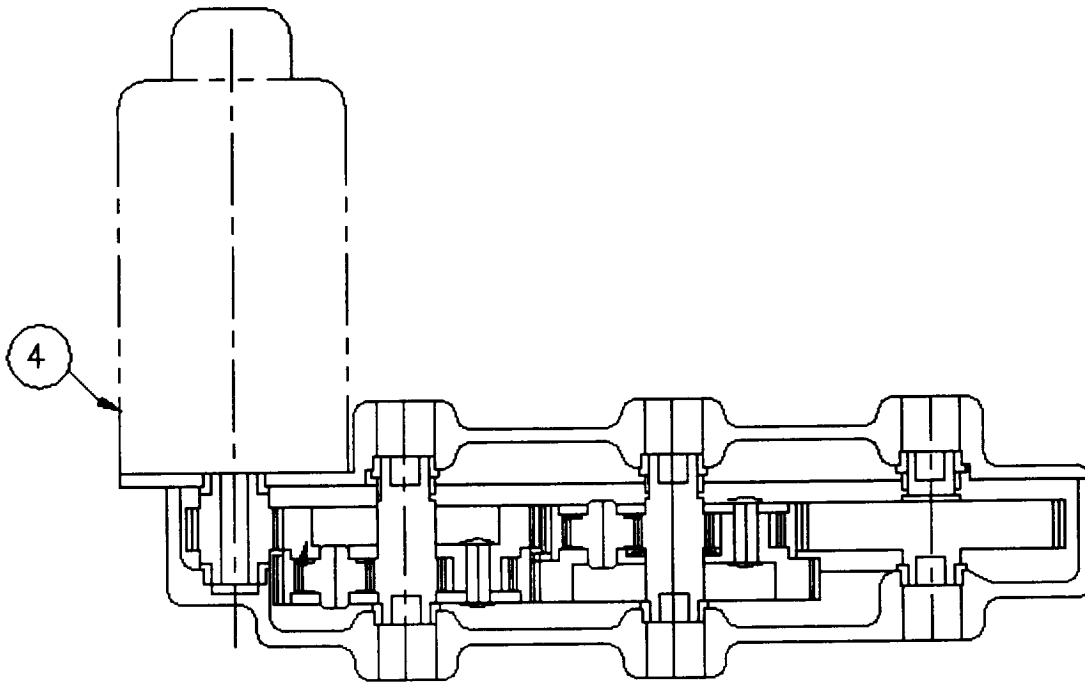
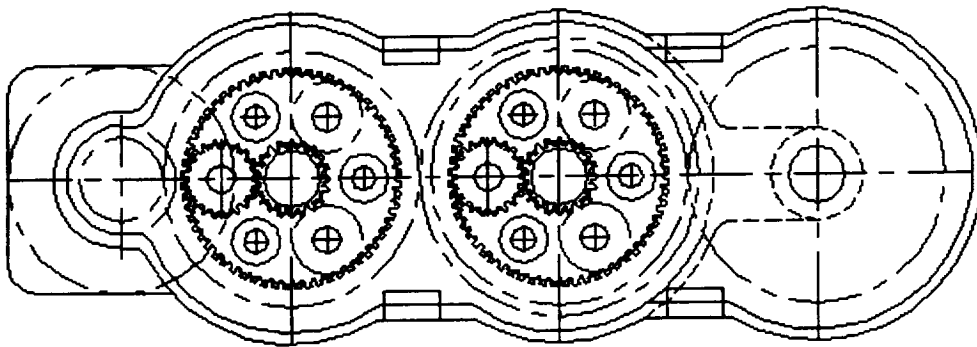
OPERATION	SUBASSEMBLE LOWER HALF WITH GEARS				
TIME CYCLE	PER ASSEMBLY				
EQUIPMENT	BENCH FIXTURE				
COST ESTIMATE					
OPERATION NO 20	4445	4446	4447	4448	AEROMOVER INC BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY
SOUTH LYON DESIGN	4449	4450	4451	4452	



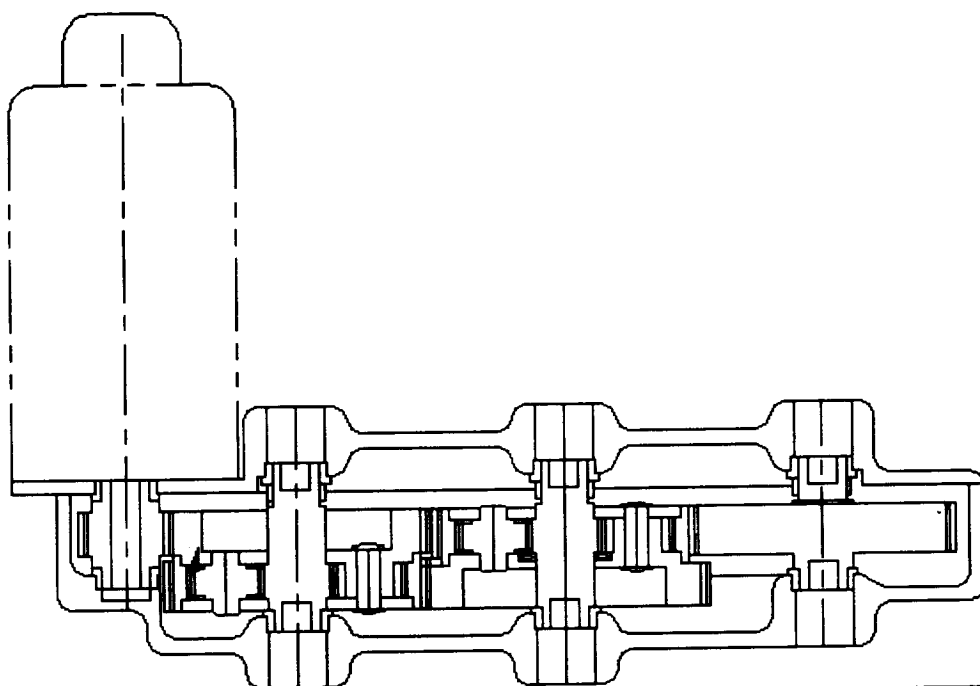
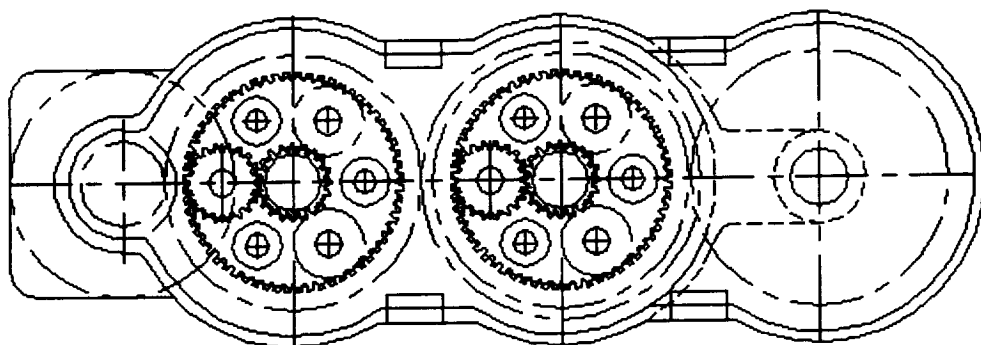
OPERATION	ASSEMBLY BRAKE (3), SOLENOID (3) & WIRING				
TIME CYCLE		PER ASSEMBLY			
EQUIPMENT	BENCH FIXTURE				
COST ESTIMATE					
OPERATION NO 30		DATE	ENGINEER	DATE	AEROMOVER INC
SOUTH LYON DESIGN					
					BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY



OPERATION	JOIN TO SUB-ASSEMBLIES AND LOAD TO PRESS PRESS TO POSITION				
TIME CYCLE		PER ASSEMBLY			
EQUIPMENT	PRESS WITH POSITION FEEDBACK				
COST ESTIMATE					
OPERATION NO 40			ENGINEER	DATE	AEROMOVER INC BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY
SOUTH LYON DESIGN					



OPERATION	MOUNT MOTOR				
TIME CYCLE		PER ASSEMBLY			
EQUIPMENT	BENCH FIXTURE				
COST ESTIMATE					
OPERATION NO 50	DATE	ENGINEER	DATE	AEROMOVER INC	
SOUTH LYON DESIGN	DATE	ENGINEER	DATE	BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY	



OPERATION	CONNECT CABLES TEST SOL., RPM, DIRECTION, & DRAG DISCONNECT CABLES & SHIP					
TIME CYCLE	PER ASSEMBLY					
EQUIPMENT	TEST MACHINE					
COST ESTIMATE						
OPERATION NO 60	1	2	3	4	5	AEROMOVER INC BRAKE ASSEMBLY FOR 3 OUTPUT SEAT ASSEMBLY
SOUTH LYON DESIGN	6	7	8	9	10	

Technical drawing of a mechanical part, showing a top view and a side view. The drawing includes dimensions in inches.

Top View Dimensions:

- Overall diameter: 1.770
- Distance from center to outer edge: 1.401
- Distance from center to inner hole: 1.165
- Distance from center to outer hole: 1.006
- Distance from center to outer hole (bottom): 1.463
- Distance from center to outer hole (right): .536
- Distance from center to outer hole (bottom right): .750
- Distance from center to outer hole (bottom left): 1.603
- Distance from center to outer hole (left): .750
- Distance from center to outer hole (top left): 1.481
- Distance from center to outer hole (top): .945
- Distance from center to outer hole (top right): .139
- Distance from center to outer hole (right): .764
- Distance from center to outer hole (bottom right): .236
- Distance from center to outer hole (bottom): 1.299
- Distance from center to outer hole (bottom left): 1.299

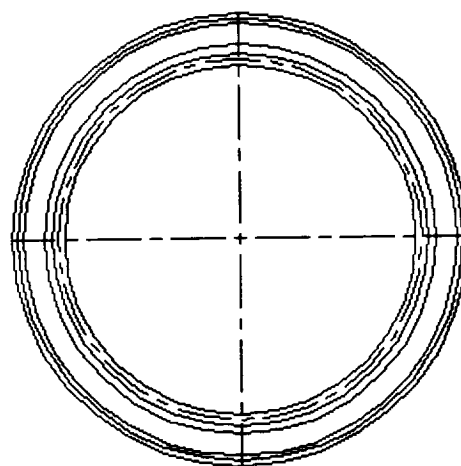
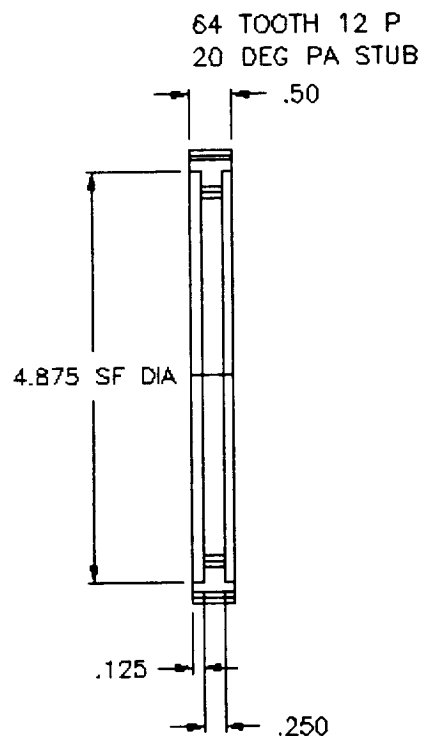
Side View Dimensions:

- Overall height: 4.56
- Distance from top to first step: .875
- Distance from top to second step: .375
- Distance from top to third step: .250
- Distance from top to bottom: 5.125
- Distance from top to bottom (inner): 4.625
- Distance from top to bottom (inner): 1.250
- Distance from top to bottom (inner): 1.500
- Distance from top to bottom (inner): 4.178
- Distance from top to bottom (inner): .46
- Distance from top to bottom (inner): .125

Notes:

- DRILL REAM & TAP FOR 1/4 SHOULDER SCREW

DIVISION		ENGINEER	DATE	AEROMOVER INC.
			SID 6/17/87	
				8 SPINDLE NUT RUNNER
				300 IN LB CAPACITY



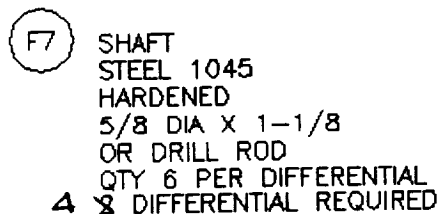
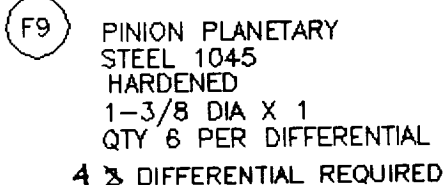
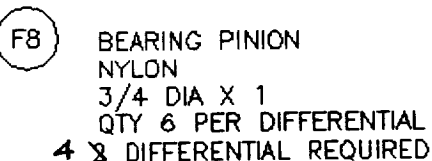
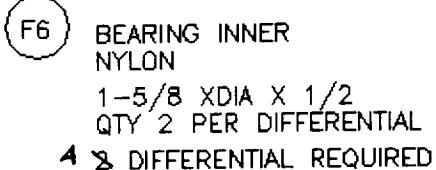
GEAR INFO	OUTER	INNER
NO OF TEETH	64	60
DIAMETRICAL PITCH	12	14
PITCH DIA	5.333	4.285

F2

GEAR
GEAR ANNULUS
STEEL 1045
HARDENED
5-1/2 DIA X 3/4
OR TUBE 5-1/2 OD X 4-3/4 ID X 3/4

QTY 2 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED

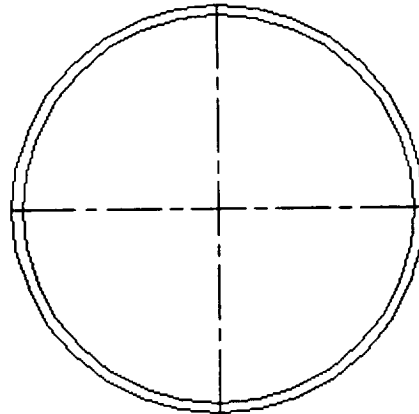
DESIGNED DRAWN CHECKED APPROVED DATE	ENGINEER	DATE	AEROMOVER INC.
		4/17/87	
8 SPINDLE NUT RUNNER 300 IN LB CAPACITY			



NO FO TEETH	18
DIAMETRICAL PITCH	14
PITCH DIA	1.285

18			ENGINEER	DATE
14				SID
1.285				4/17/87

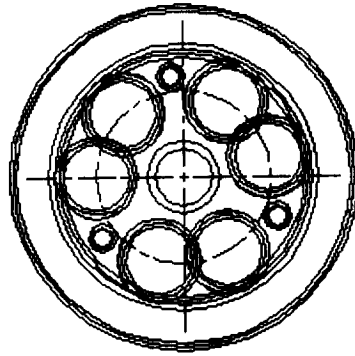
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



BEARING OUTER
NYLON
5 OD X 4-1/2 ID X 1/4
QTY 4 PER DIFFERENTIAL
4 X DIFFERENTIAL REQUIRED

AEROMOVER INC.

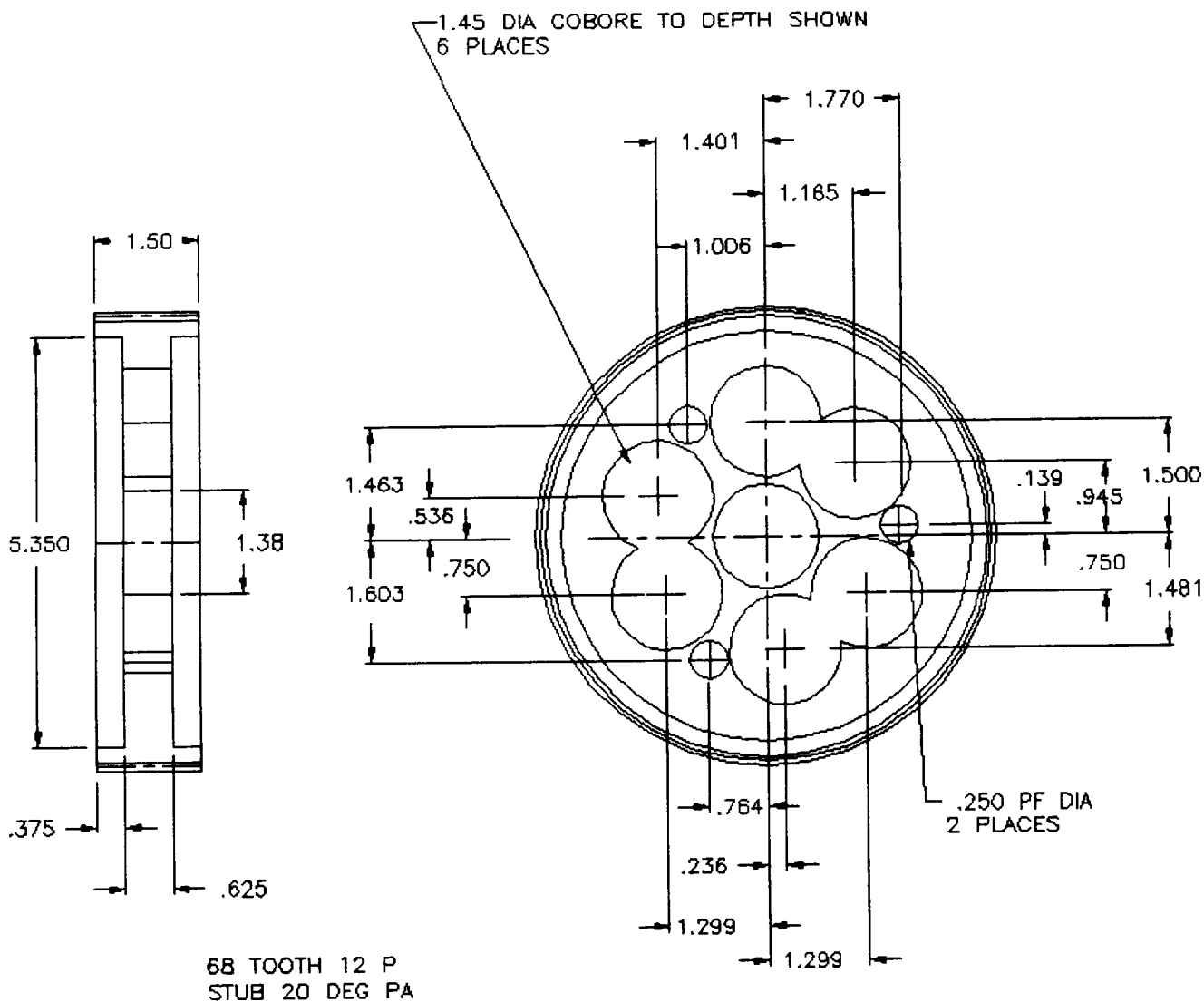
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



INTERMEDIATE DIFFERENTIAL ASSEMBLY

SYM	QTY	DESCRIPTION
X1	1	GEAR CENTER
X2	6	SHAFT
X3	6	BEARING PINION
X4	6	PINION PLANETARY
X5	3	3/8 SHOULDER SCR
F1	1	HSG OUTER
F6	2	RRG INNER

QUANTITY (2)
SLD 2/21/97



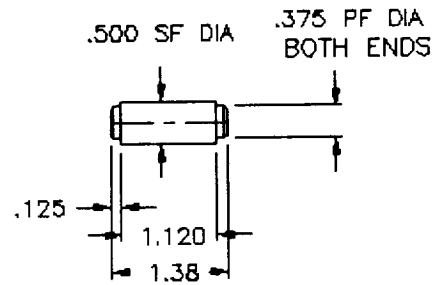
GEAR INFO

NO OF TEETH	68
DIAMETRICAL PITCH	12
PITCH DIAMETER	5.666

(X1)

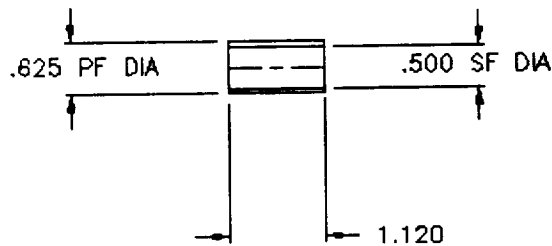
CENTER GEAR
STEEL 1045
HARDENED
6 DIA X 1-3/4
QTY 1 PER DIFFERENTIAL
2 DIFFERENTIAL REQUIRED

QTY	DESCRIPTION	UNIT	ENGINEER	DATE	AEROMOVER INC.
				3.0	
				4/17/97	8 SPINDLE NUT RUNNER 300 IN LB CAPACITY



(X2)

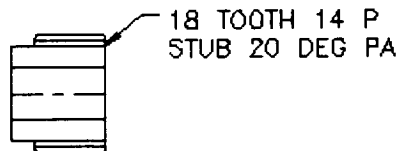
PINION SHAFT
STEEL 1045
OR DRILL ROD
1/2 DIA X 1-1/2
QTY 6 PER DIFFERENTIAL B
2 DIFFERENTIAL REQUIRED



(X3)

BEARING PINION
NYLON
3/4 DIA X 1-1/2
6 REQUIRED PER DIFFERENTIAL
~~1 DIFFERENTIAL REQUIRED~~
2 DIFFERENTIAL REQUIRED

D I D I
--



GEAR INFO

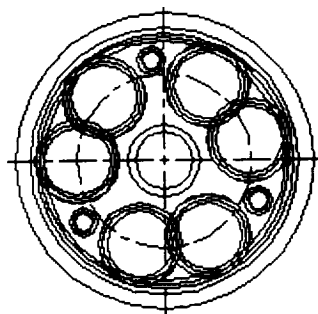
NO OF TEETH 18
DIAMETRICAL PITCH 14
PITCH DIAMETER 1.285

X4

PINION PLANETARY
STEEL 1045
HARDENED
1-1/2 DIA X 1-1/2
QTY 6 PER DIFFERENTIAL
2 DIFFERENTIAL REQUIRED

DATE	ENGINEER	DATE	S.D.	4/17/97	AEROMOVER INC.
8 SPINDLE NUT RUNNER					
300 IN LB CAPACITY					

60 TOOTH 14 P
STUB 20 DEG PA



SYM	QTY	DESCRIPTION	GENERAL PROTON OUTPUT
M1	2	HSG OUTER	
M2	1	HSG OUTER	
M3	1	CENTER	
X2	6	SHAFT	
X3	6	BEARING PINION	
X4	6	PINION PLANETARY	
M4	3	3/8 SHOULDER SCR	
F6	4	BRC INNER	
M5	1	HSG OUTER	

DETAILS COMPONENTS

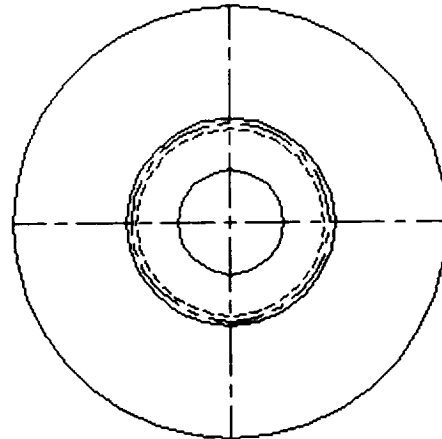
INPUT DIFFERENTIAL ASSEMBLY

ASSEMBLY
SECTION

EXTERNAL

AEROMOVER INC.

**8 SPINDLE NUT RUNNER
300 IN LB CAPACITY**

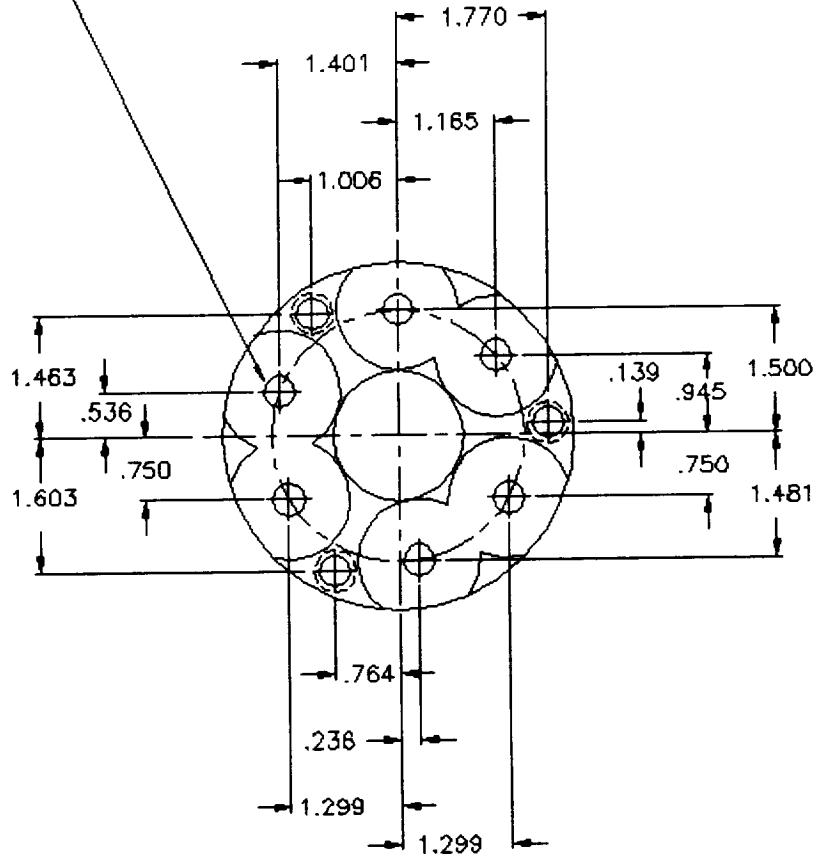
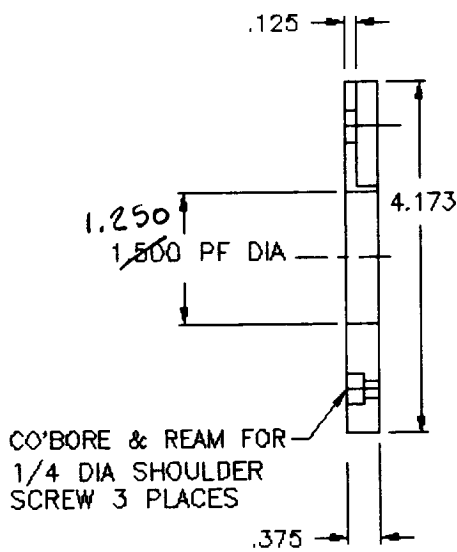


~~PINION~~ MTR GEAR OUTPUT
STEEL 1045
HARDENED
5-1/4 DIA X 2
QTY 2 REQUIRED PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

GEAR INFO	INTERNAL	EXTERNAL
NO OF TEETH	60	28
DIAMETRICAL PITCH	14	12
PITCH DIAMETER	4.285	2.333

D 11 10 9 8 7 6 5 4 3 2 1		ENGINEER	DATE	AEROMOVER INC.
			S.D. 4/17/87	
				8 SPINDLE NUT RUNNER
				300 IN LB CAPACITY

.375 SF DIA THRU
1.45 DIA COBORE TO DEPTH SHOWN
6 PLACES



CHANGE TO
PLANET CARRIER

M2

HSC OUTER
~~HSC~~ OUTER CARRIER
STEEL 1045
4-1/4 DIA X 3/4
QTY 1 PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

REV	DESCRIPTION	ENGINEER	DATE	AEROMOVER INC.	
1			4/17/97	8 SPINDLE NUT RUNNER	
2				300 IN LB CAPACITY	
3					
4					
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6					
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9					
10					



STEEL 1045
5-1/4 DIA X 3/4
QTY 1 PER DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

DATE	ENGINEER	DATE	AEROMOVER INC.
		SLD	
4/17/87			8 SPINDLE NUT RUNNER
			300 IN LB CAPACITY

Technical drawing of a circular mechanical part, likely a valve plate, showing dimensions and a callout for a specific feature.

Dimensions:

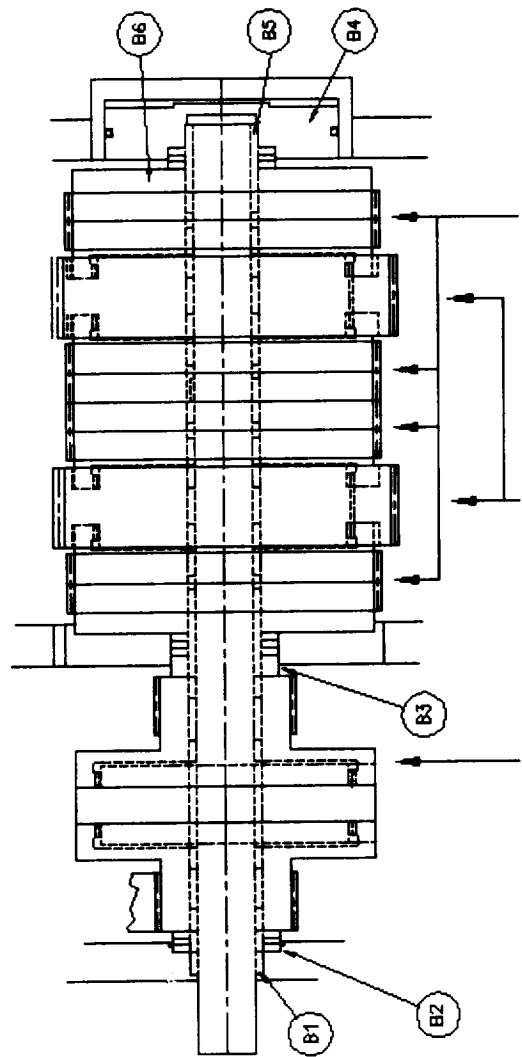
- Overall diameter: 1.770
- Inner diameter (dashed circle): 1.401
- Distance from center to outer edge (horizontal): 1.165
- Distance from center to outer edge (vertical): 1.006
- Distance from center to outer edge (diagonal): 1.463
- Distance from center to outer edge (diagonal): .536
- Distance from center to outer edge (diagonal): .750
- Distance from center to outer edge (diagonal): 1.603
- Distance from center to outer edge (diagonal): 1.481
- Distance from center to outer edge (diagonal): .764
- Distance from center to outer edge (diagonal): .236
- Distance from center to outer edge (diagonal): 1.299
- Distance from center to outer edge (diagonal): 1.299
- Distance from center to outer edge (diagonal): .750
- Distance from center to outer edge (diagonal): .139
- Distance from center to outer edge (diagonal): .945
- Distance from center to outer edge (diagonal): 1.500

Callout: DRILL REAM & TA 1/4 SHOULDER

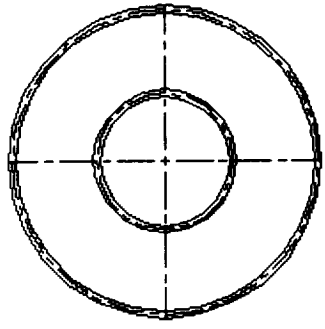
Technical drawing of a shaft with the following dimensions: 3.75, .250, 1.250, 1.500 DIA, and 4.178.

HSG INNER
STEEL 1045
4-1/4 DIA X 1/2
QTY 1 PRE DIFFERENTIAL
1 DIFFERENTIAL REQUIRED

			ENGINEER	DATE SLD 4/17/82	AEROMOVER INC.
					8 SPINDLE NUT RUNNER 300 IN LB CAPACITY

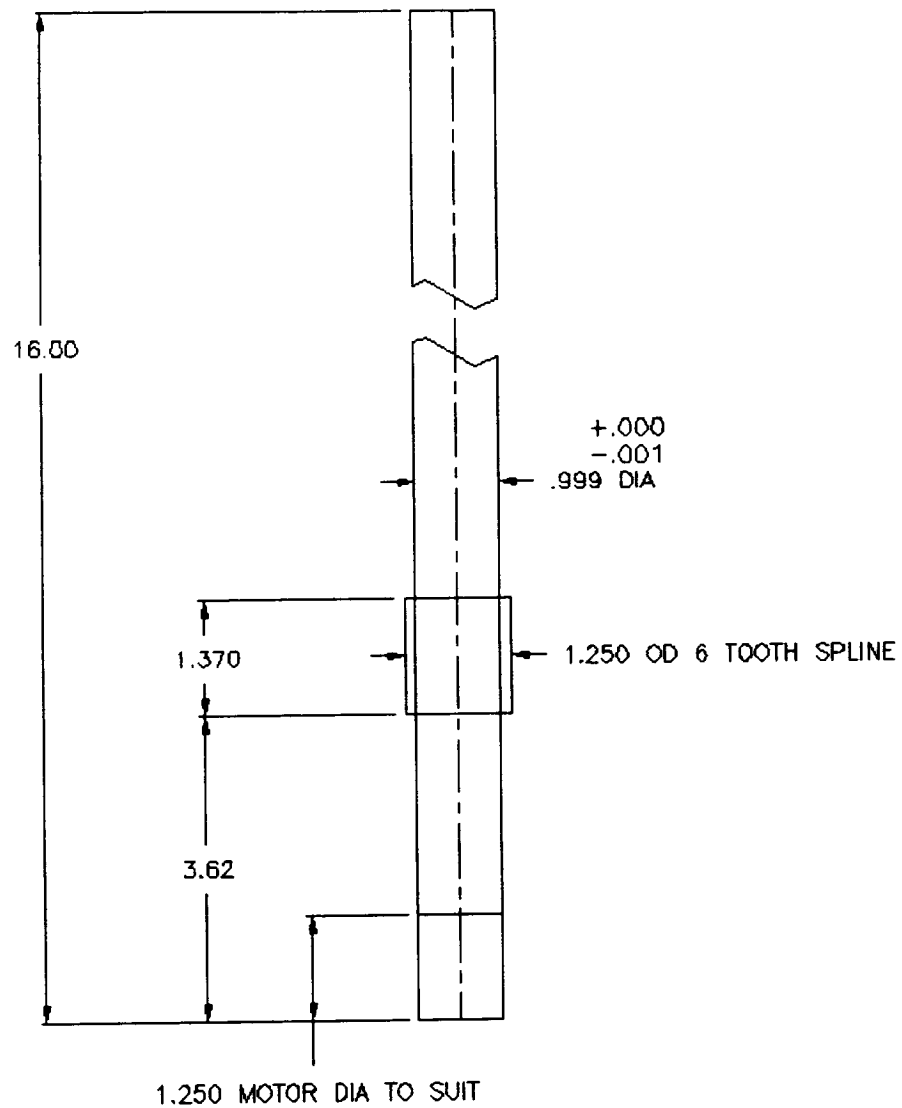


INPUT QTY (1) INTERMEDIATE QTY (2) FINAL QTY (4)
 DIFFERENTIAL ASSEMBLY LAYOUT



SYM	QTY	DESCRIPTION
B1	1	SHAFT
B2	3	BRG THRUST
B3	1	SPACER
B4	1	PISTON
B5	2	BUSHING
B6	2	CAP
B7	1	O-RING

AEROMOVER INC.	
8 SPINDLE NUT RUNNER	
300 IN LB CAPACITY	

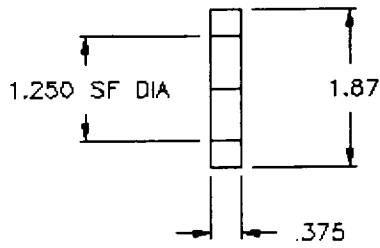


(B1)

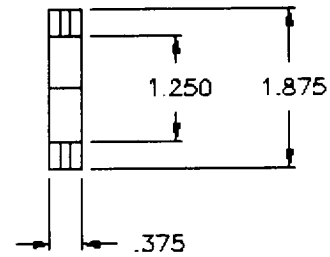
SHAFT
STEEL 1020
1-1/4 DIA X 16-1/4
QTY 1

AEROMOVER INC.					
8 SPINDLE NUT RUNNER 300 IN LB CAPACITY					
<table border="1"> <tr> <th>ENGINEER</th> <th>DATE</th> </tr> <tr> <td>S.D.</td> <td>4/17/87</td> </tr> </table>	ENGINEER	DATE	S.D.	4/17/87	
ENGINEER	DATE				
S.D.	4/17/87				

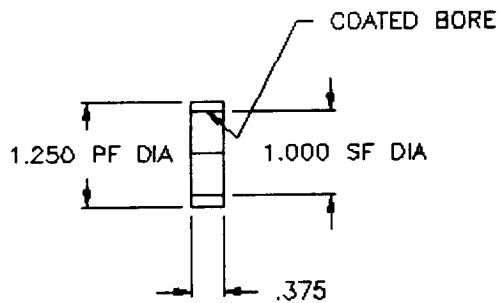
REVISIONS



(B3) SPACER
CRS
1-7/8 DIA X 1/2
QTY 1



(B2) THRUST BEARING
NEEDLE TYPE
COMMERICAL
QTY 3



(B1) BUSHING
CRS
1-3/8 DIA X 1/2
QTY 2

NO.	DESCRIPTION	ENGINEER	DATE
1		S.D.	4/17/87
2			
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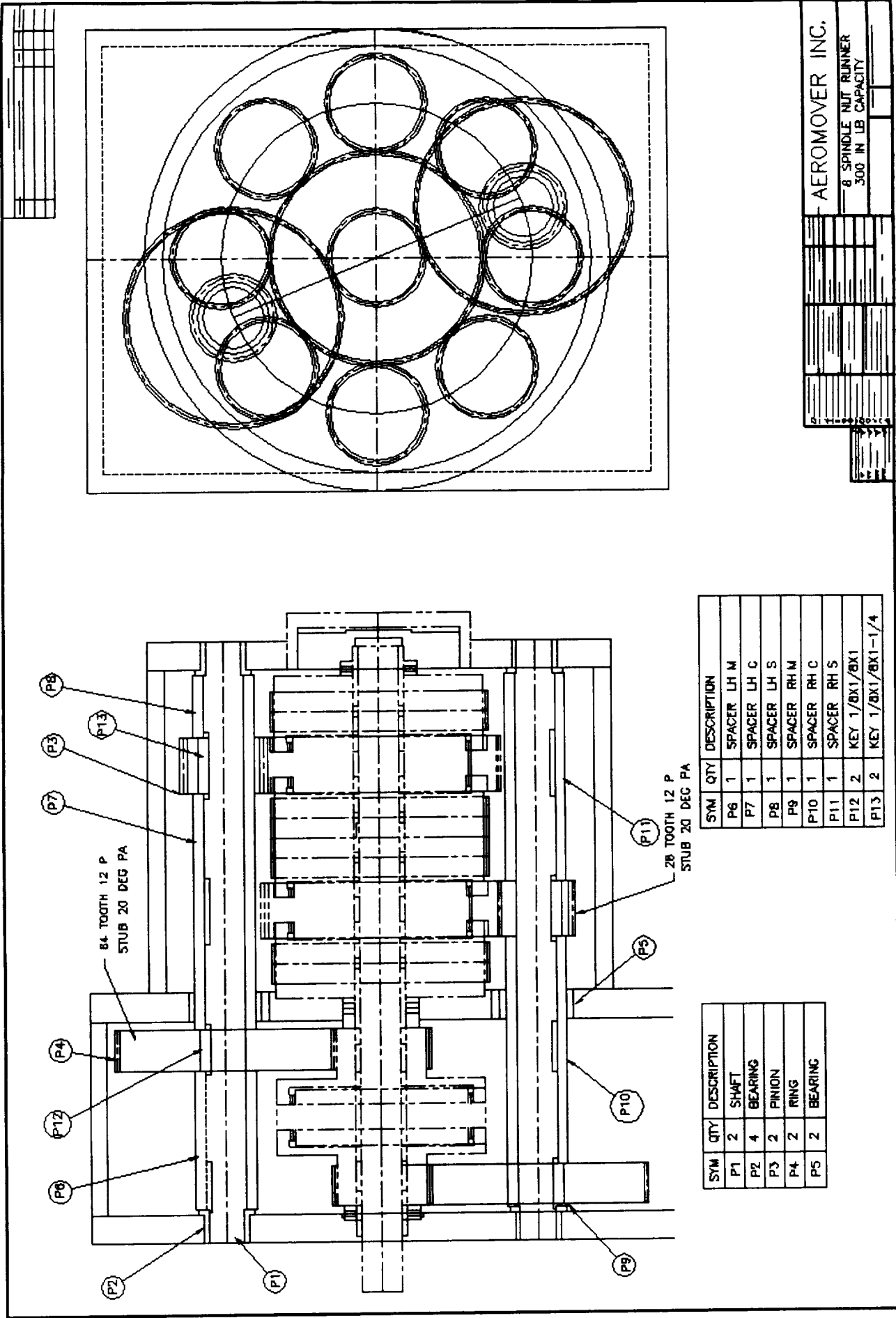
AEROMOVER INC.

8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



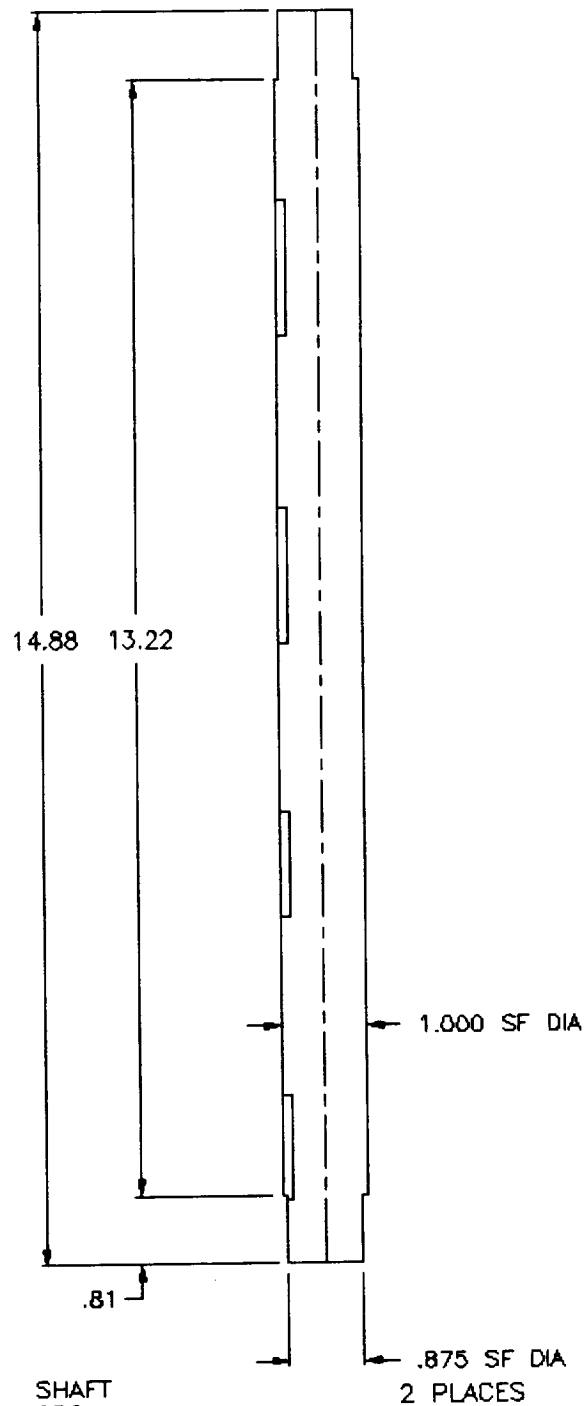
PISTON
ALUM
4-1/4 DIA 1
QTY 1

		ENGINEER	DATE	AEROMOVER INC.
		S.L.D	4/17/87	
				8 SPINDLE NUT RUNNER
				300 IN LB CAPACITY



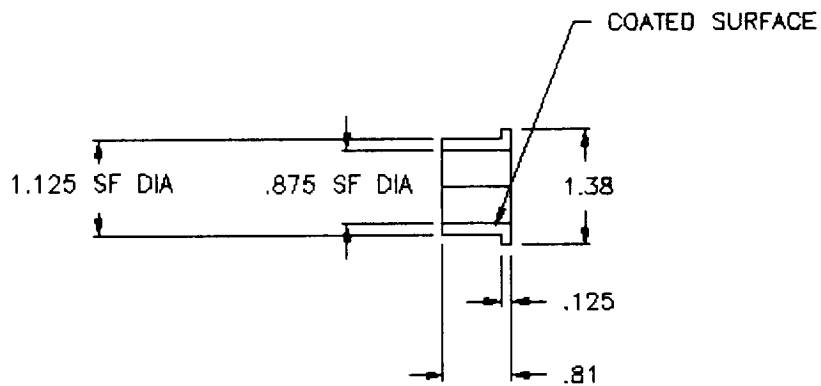
SYM	QTY	DESCRIPTION
P1	2	SHAFT
P2	4	BEARING
P3	2	PINION
P4	2	RING
P5	2	BEARING

SYM	QTY	DESCRIPTION
P6	1	SPACER LH M
P7	1	SPACER LH C
P8	1	SPACER LH S
P9	1	SPACER RH M
P10	1	SPACER RH C
P11	1	SPACER RH S
P12	2	KEY 1/8X1/8X1
P13	2	KEY 1/8X1/8X1-1/4



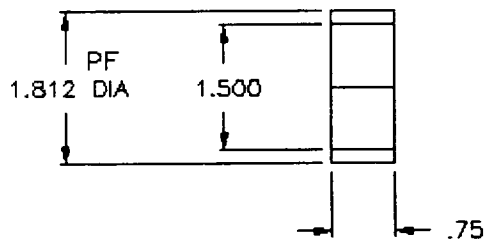
SHAFT
CRS
1.00 DIA X 15
QTY 2

11 10 9 8 7 6 5 4 3 2 1		ENGINEER	DATE	AEROMOVER INC. 8 SPINDLE NUT RUNNER 300 IN LB CAPACITY
		S.D.	4/17/87	



(P2)

BEARING
CRS
1-3/8 DIA X 1
QTY 4

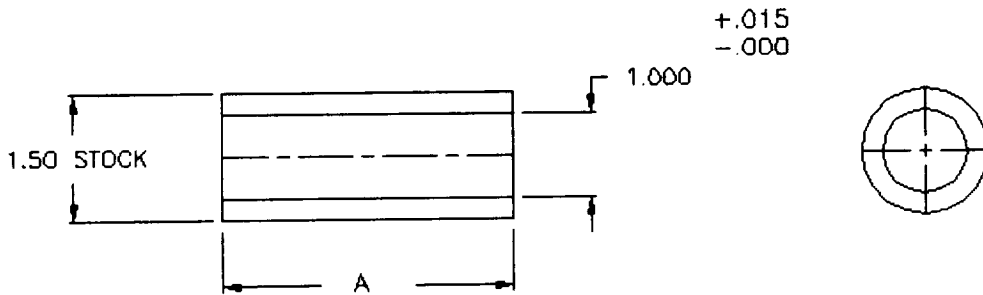


(P5)

BEARING
CRS
2 DIA X 1
QTY 2

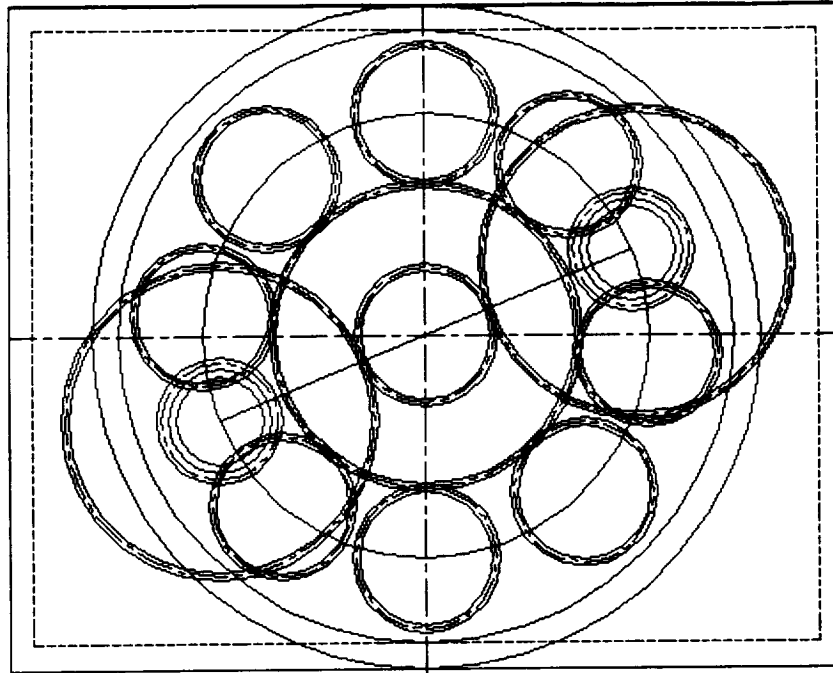
REVISIONS		ENGINEER	DATE	AEROMOVER INC.	
NO.	DESCRIPTION	BY	DATE		
1			4/17/87	8 SPINDLE NUT RUNNER 300 IN LB CAPACITY	
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Q T H E C O L U M N		ENGINEER	DATE	AEROMOVER INC.
		SLO	4/17/87	
				8 SPINDLE NUT RUNNER
				300 IN LB CAPACITY



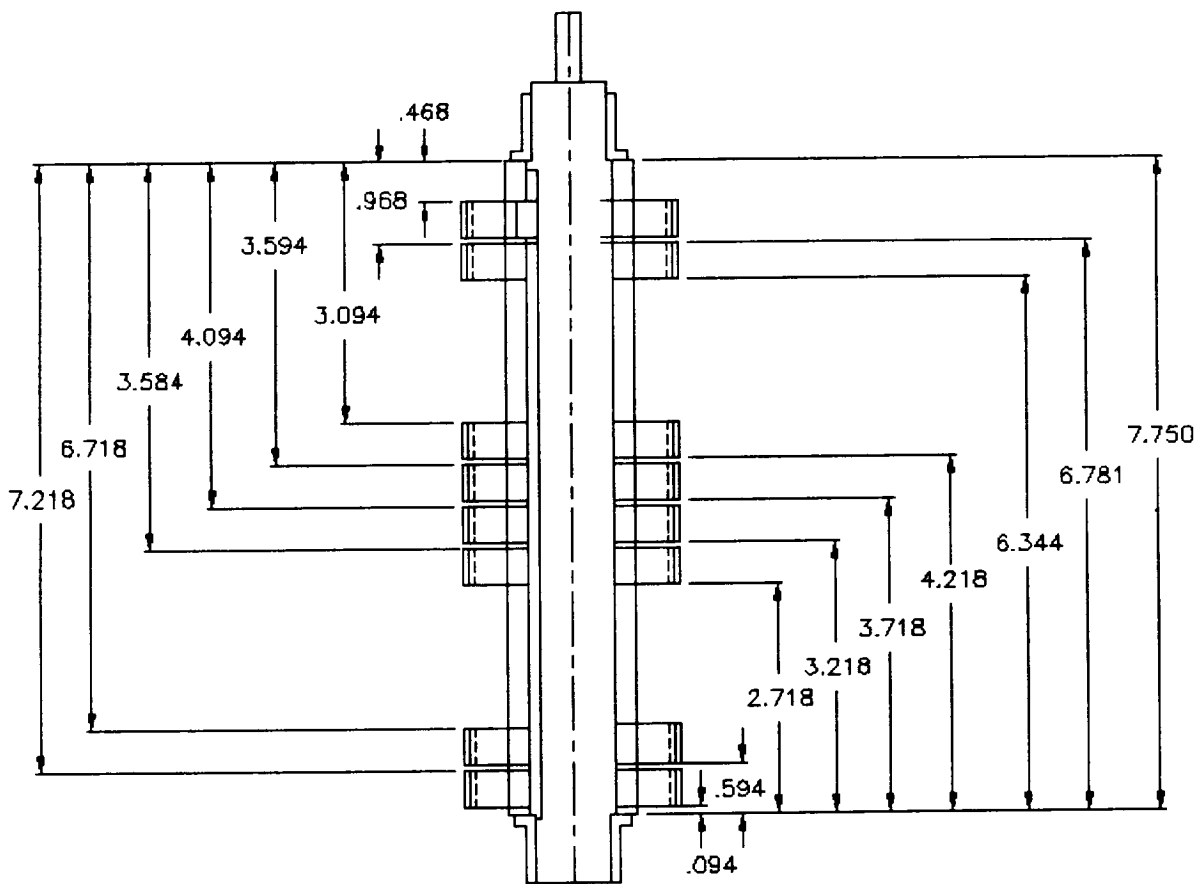
PART NO	DIM A
P6	3.437
P7	5.875
P8	1.562
P9	.062
P10	5.625
P11	5.187

1. TITLE 2. DATE 3. DRAWN BY 4. CHECKED BY 5. APPROVED BY		ENGINEER SLD	DATE 4/17/87	AEROMOVER INC. 8 SPINDLE NUT RUNNER 300 IN LB CAPACITY



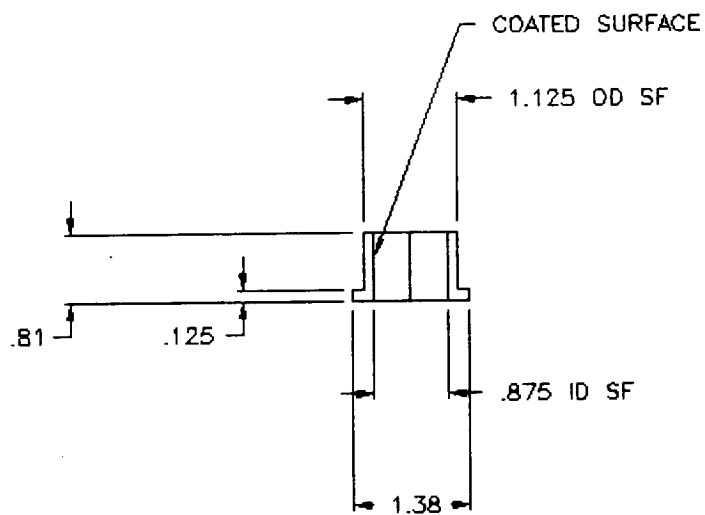
SYM	QTY	DESCRIPTION
S1	16	BUSHING
S2	8	GEAR
S3	8	SHAFT
S4	16	JOINT
S5	8	SHAFT TO SUIT APPLIC.

AEROMOVER INC.
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



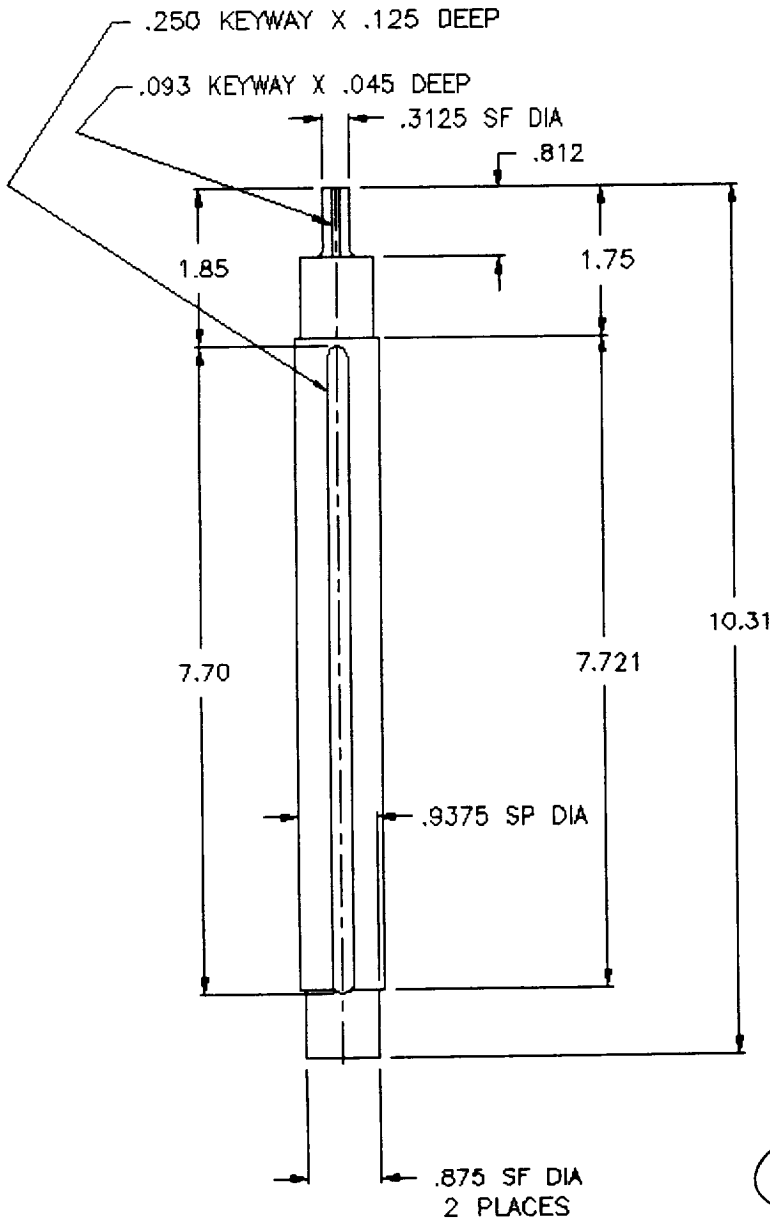
SPACER LAYOUT DRAWING

REVISIONS		ENGINEER	DATE	AEROMOVER INC.
1		SLD	4/17/87	
2				8 SPINDLE NUT RUNNER 300 IN LB CAPACITY
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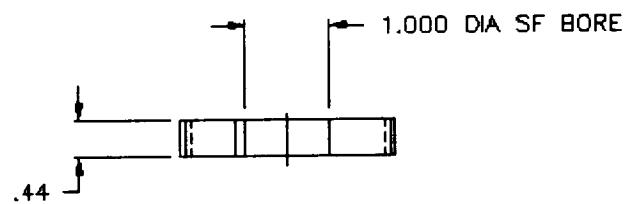
(S1) BUSHING
CRS
1-3/8 DIA X 1
QTY 16

ID		ENGINEER		DATE		AEROMOVER INC.	
SLO		SLO		4/17/87			
1		1		1		8 SPINDLE NUT RUNNER	
2		2		2		300 IN LB CAPACITY	
3		3		3			
4		4		4			
5		5		5			
6		6		6			
7		7		7			
8		8		8			
9		9		9			
10		10		10			



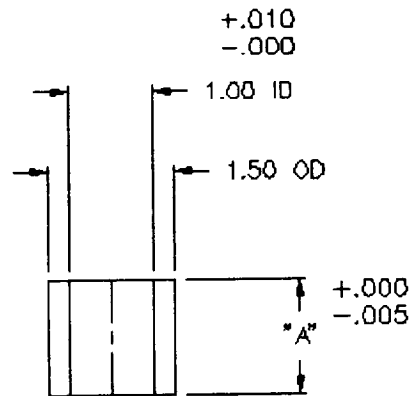
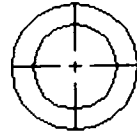
(S3) SHAFT
STEEL 1020
1 DIA X 10-1/2
QTY 8

ENGINEER		DATE		AEROMOVER INC.	
10		BLD	4/17/87		
11				8 SPINDLE NUT RUNNER 300 IN LB CAPACITY	
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GEAR
STEEL 1045
HARDENED
3.00 DIA X 9/16
QTY 8

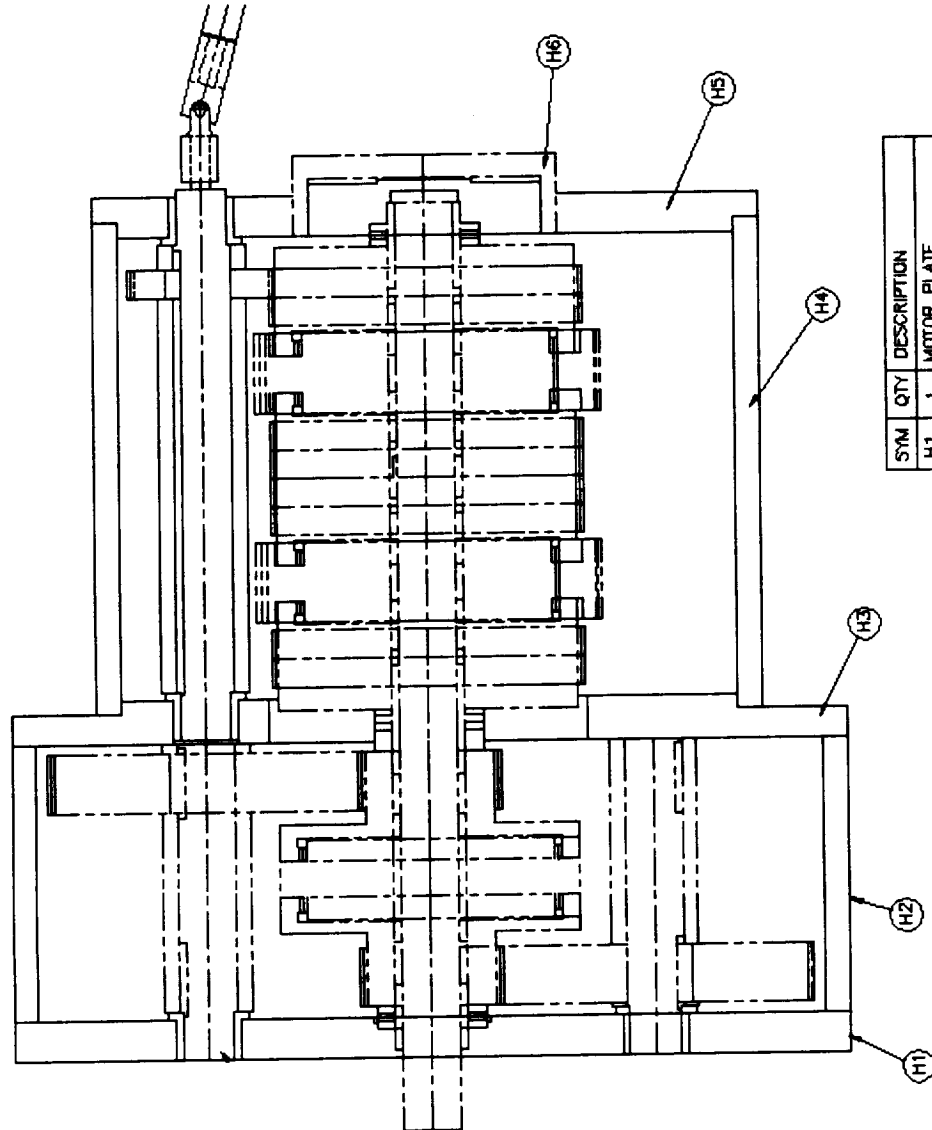
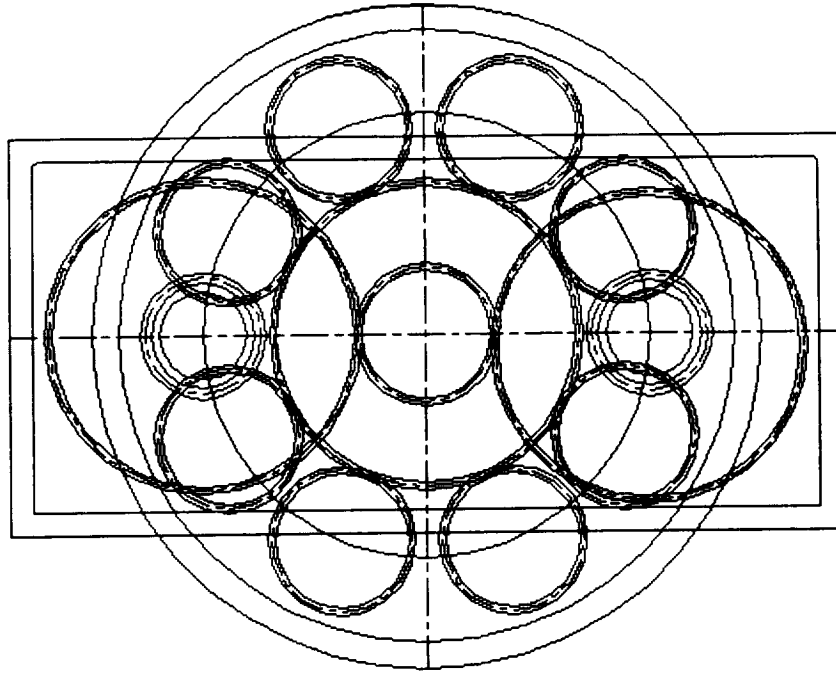
ID		ENGINEER	DATE	AEROMOVER INC.
		S.D.	4/17/87	
V				8 SPINDLE NUT RUNNER 300 IN LB CAPACITY
T				
O				
C				
R				
D				
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A				
P				
P				
M				
N				
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PART NO.	SPL#	F/R	DIM "A"
S6	1	F	.468
S7	1	R	6.344
S8	2	F	.968
S9	2	R	6.781
S10	3	F	3.094
S11	3	R	4.218
S12	4	F	3.594
S13	4	R	3.718
S14	5	F	4.094
S15	5	R	3.218
S16	6	F	3.584
S17	6	R	2.718
S18	7	F	6.718
S19	7	R	.594
S20	8	F	7.218
S21	8	R	.094

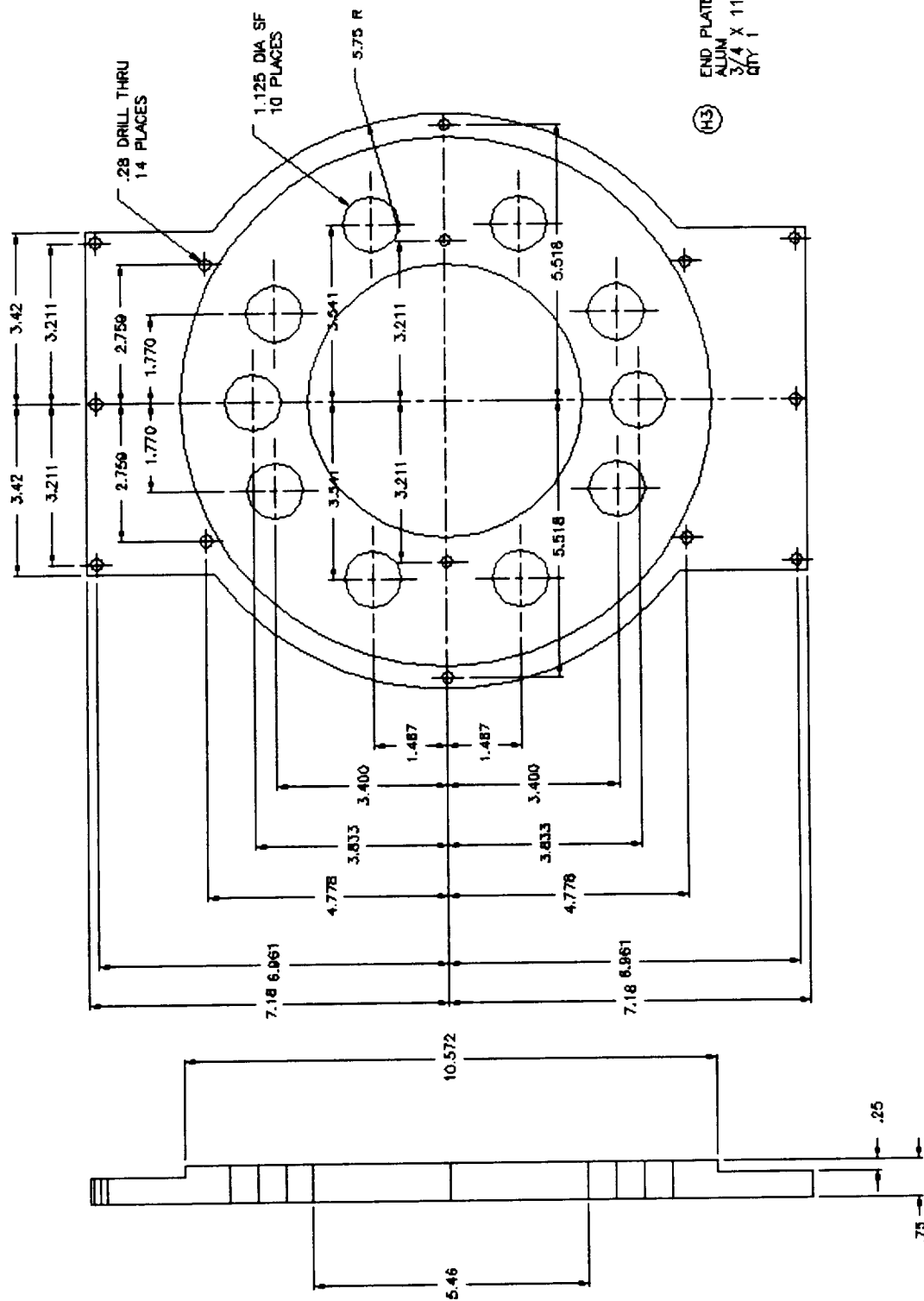
QUANTITY (1) FO EACH

110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128 129 130 131 132 133 134 135 136 137 138 139 140 141 142 143 144 145 146 147 148 149 150 151 152 153 154 155 156 157 158 159 160 161 162 163 164 165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200 201 202 203 204 205 206 207 208 209 210 211 212 213 214 215 216 217 218 219 220 221 222 223 224 225 226 227 228 229 230 231 232 233 234 235 236 237 238 239 240 241 242 243 244 245 246 247 248 249 250 251 252 253 254 255 256 257 258 259 260 261 262 263 264 265 266 267 268 269 270 271 272 273 274 275 276 277 278 279 280 281 282 283 284 285 286 287 288 289 290 291 292 293 294 295 296 297 298 299 300	ENGINEER SLD	DATE 4/17/87	AEROMOVER INC. 8 SPINDLE NUT RUNNER 300 IN LB CAPACITY
	301 302 303 304 305 306 307 308 309 310 311 312 313 314 315 316 317 318 319 320 321 322 323 324 325 326 327 328 329 330 331 332 333 334 335 336 337 338 339 340 341 342 343 344 345 346 347 348 349 350 351 352 353 354 355 356 357 358 359 360 361 362 363 364 365 366 367 368 369 370 371 372 373 374 375 376 377 378 379 380 381 382 383 384 385 386 387 388 389 390 391 392 393 394 395 396 397 398 399 400		

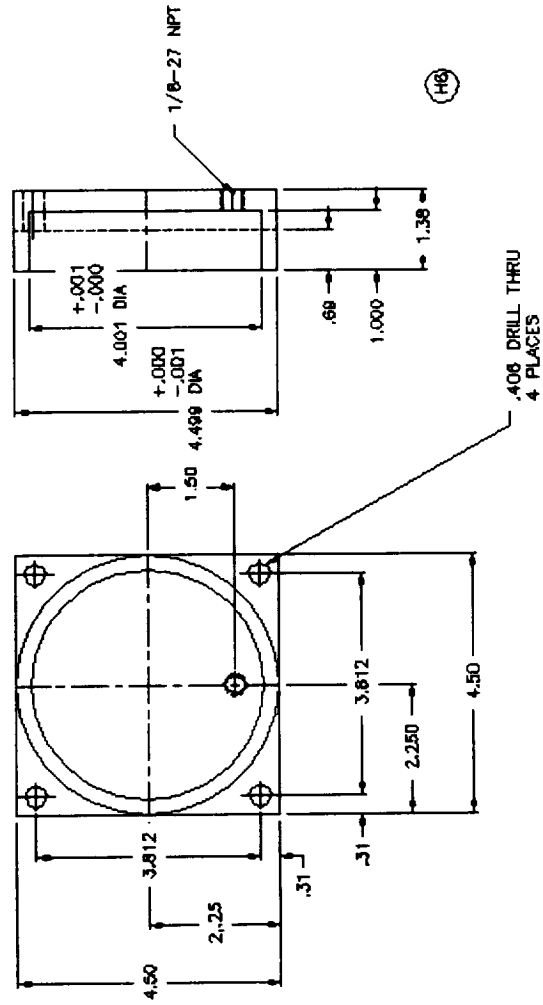


SYM	QTY	DESCRIPTION
H1	1	MOTOR PLATE
H2	1	MOTOR SPACER
H3	1	END PLATE
H4	1	CYLINDER
H5	1	END PLATE
H6	1	PISTON HOUSING

AEROMOVER INC.
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



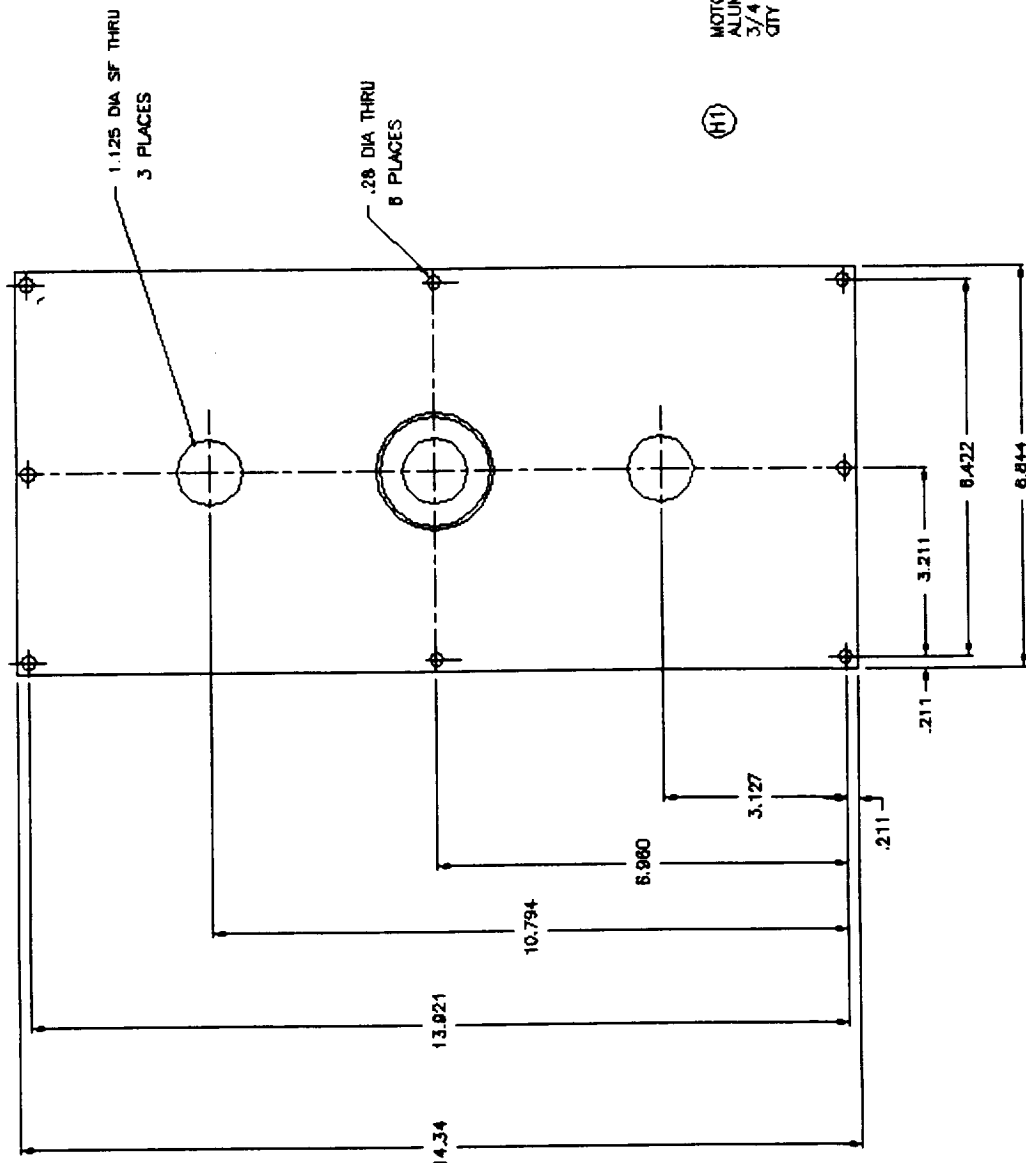
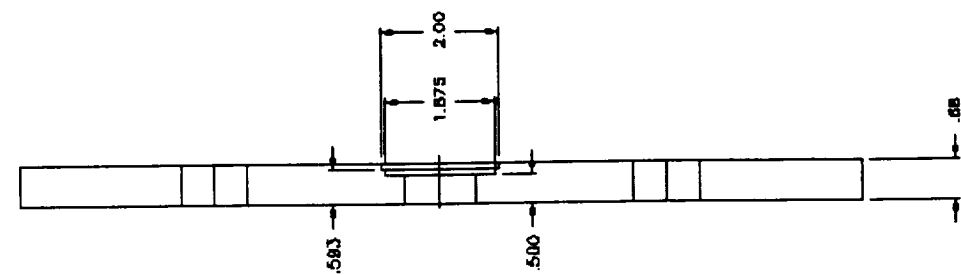
-AEROMOVER INC.



PISTON HOUSING
ALUM.
5 DIA X 1-1/2
QTY 1

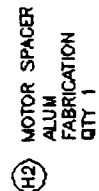
(HB)

AEROMOVER INC.
8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



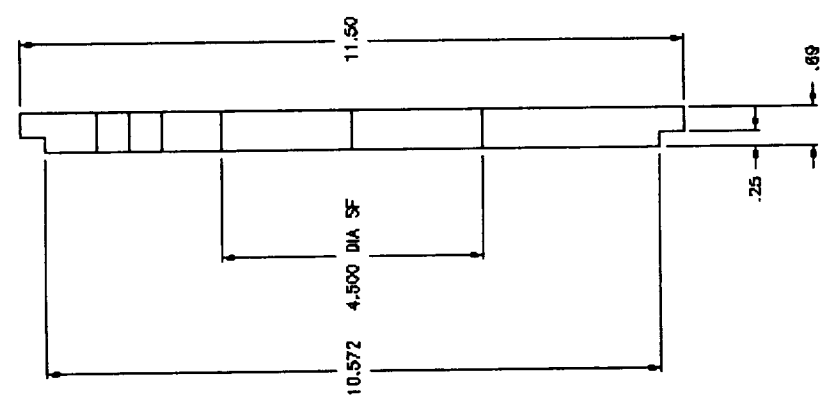
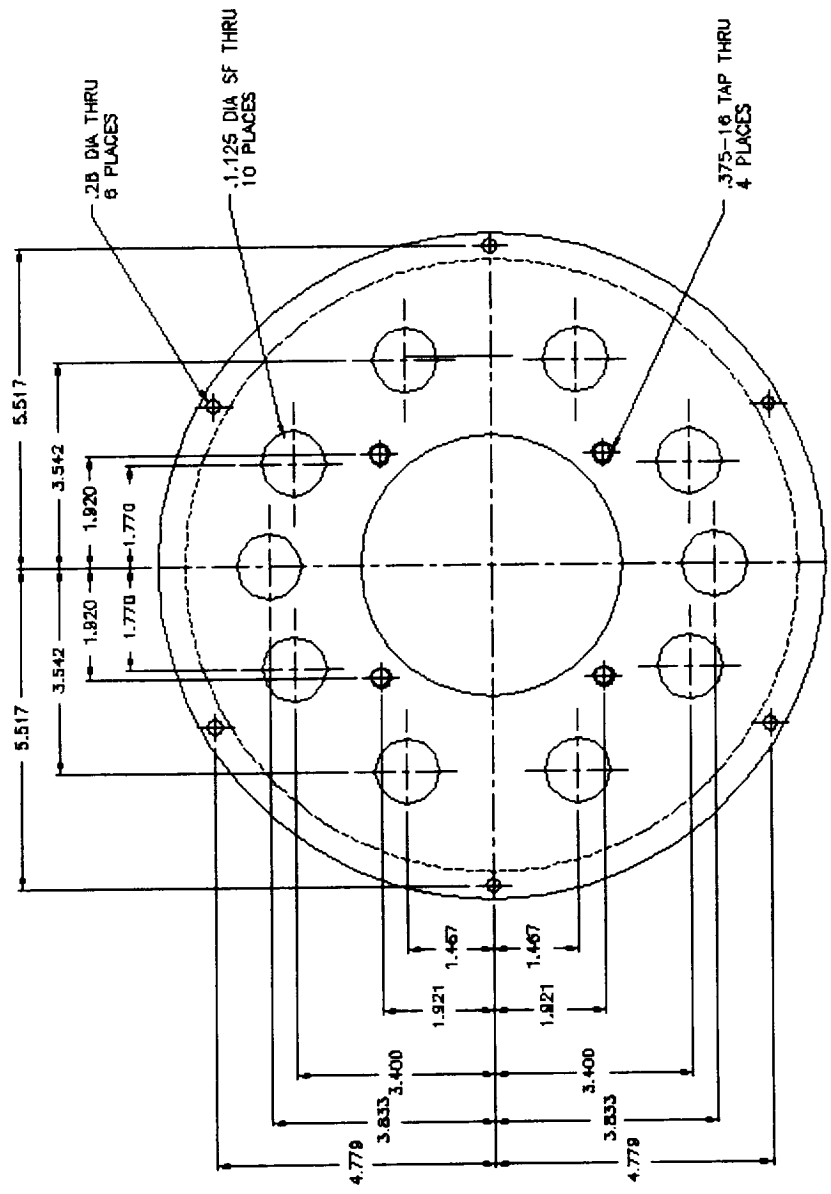
(H1)
 MOTOR PLATE
 ALUM
 3/4 X 7 X 14-1/2
 QTY 1

AEROMOVER INC.	
8 SPINDLE NUT RUNNER	
300 IN LB CAPACITY	
1	1
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49	49
50	50



AEROMOVER INC.

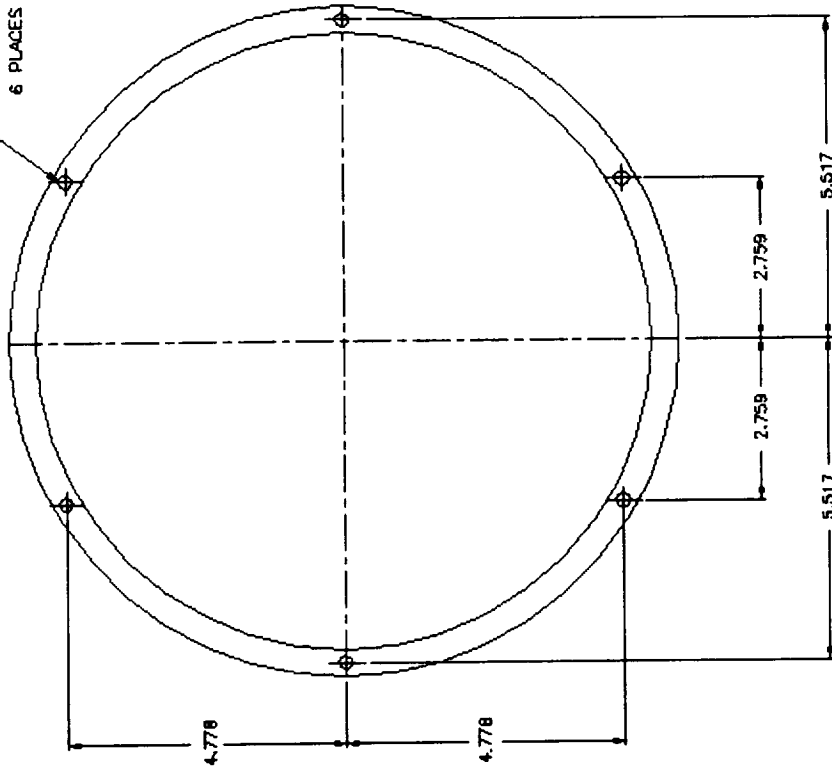
— 8 SPINDLE NUT RUNNER
300 IN LB CAPACITY



(H5)
END PLATE
ALUM.
11-1/2 DIA X 3/4
QTY 1

AEROMOVER INC.	
8 SPINDLE NUT RUNNER	
300 IN LB CAPACITY	

.25-.20 TAP .62 DEEP
6 PLACES



(H4) CYLINDER
ALUM
11-1/2 OD X 10-1/2 ID X 8-3/4
QTY 1

AEROMOVER INC.
8 SPINDLE NOT RUNNER
300 IN LB CAPACITY